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The average person who thinks about Philippine weather and the winds that influence it has heard of the "*Nortes*" and typhoons, and recalls the prevalence of a wind from the south in some places during the months of March and April, but that is generally as far as his knowledge extends.

I. Air Masses

Actually there are six winds or "air masses" that affect Philippine weather, and the typhoon is not one of them. They are the Northeast Monsoon, the Northeast Trade, the South Pacific Trade, the North Indian Westerlies, the South Indian Westerlies and the Temperate Zone Westerlies.

Two of these, the North Indian Westerlies and the Temperate Zone Westerlies, can be omitted from this study as of comparatively little importance. Of the others the South Indian Westerlies and the South Pacific Trade, since they ordinarily strike the Philippines either as *one* wind or at least as hardly distinguishable winds, will be grouped loosely under the title "The Southwest Monsoon".

Therefore in a study of Philippine weather there are three big winds or air streams that must be considered: the Northeast Monsoon, the North Pacific Trade and the Southwest Monsoon.

Concerning the names of these air masses, "monsoon" was originally the name given by the Arabs to those seasonal winds of the Arabian Sea which blow for approximately six months from the northeast and six months from the southwest. The name (Arabic *mausim* = season) has been extended to seasonal winds in other parts of the world.

"Trade" carries a similar note of regularity. It is the name given to the regular northeasterly and southeasterly winds which blow from the temperate zone of high pressure towards the equatorial belt of low pressure. Their regularity especially over the oceans explains their name, the term *trade* being used in the otherwise obsolete sense of "course" (cf. *tread*). Now, something about each of these air masses or winds.

The Northeast Monsoon

The name of this wind is misleading as indicative of its source, for it really originates (to a Filipino observer) in the northwest, in a vast high pressure area around Manchuria and adjacent regions. At this source a huge dome of heavy air created by the low winter temperatures bears like a wedge against the air adjacent to it and pours itself out in clockwise moving streams, one of which is the Northeast Monsoon, whose first movement is rather easterly.

From November to January this wind is almost continuously dominant over eastern Asia and the Philippines; by the end of February its influence over the Philippines begins to wane. The Northeast Monsoon as has been noted, starts as a northwest or west wind near Korea. Then the stream divides. One branch proceeds eastward towards Alaska, under the attraction of a low in that area; the other loops out over

the Pacific toward a broad belt of lower pressure further south, bending gradually to follow a due north-south direction and finally swinging still further on a curve to reach the Philippines as a northeast, or an east northeast or even an east wind. These are the Philippines' famous *"Nortes."*

During the months of December and January this Northeast Monsoon blows over the whole archipelago; in September, October and November, and February, March and April it affects only parts of Luzon. The Northeast Monsoon can be quite brisk, even of gale force, especially in the China Sea and on the east coast of the Philippines. But for the rest of the islands its force is considerably tempered by the interposition of mountain barriers.

The Northeast Monsoon, or Northers or *Nortes* as it is variously called, is the Islands' coldest air stream, the mean temperature ranging from 16°C in Northern Luzon to about 20°C in Mindanao (61° to 68° F). Though these temperatures are relatively cool for the Philippines, they cannot compare with the much lower temperature of nearby Hongkong. The reason for this difference is found in the different paths pursued by the Northeast Monsoon in reaching the two destinations. It approaches Hongkong rather directly over the Asiatic continent from its frigid source, whereas it only reaches the Philippines after long wandering over the tempering waters of the Pacific.

Except for occasional deepening due to increasing pressure from the "high" source, as a rule the Northers are not more than one or two kilometers deep over the Philippines, giving the country only a "skin-deep" winter. Above this layer of *Nortes* is usually found the warmer Trade to be discussed below. Rapid loss of heat from the earth's surface by radiation to the sky takes place on clear nights unchecked by cloud insulation, and consequently the nights are quite chilly.

This Northeast Monsoon is very dry when it leaves the frozen land source of Asia. Nevertheless it soon

picks up moisture over the Ocean, which moisture however is confined to the two-kilometer depth of the Northeast Monsoon by an inversion, above which the air of the Trade Wind remains remarkably dry. By an inversion is meant a region where the usual cooling of air with increasing altitude is interrupted for a while by a layer of warmer air. The rising air of the Northwest Monsoon is stopped at the lower surface of the Trade where there is such a layer of warmer air or inversion. Its causes are too complicated to explain here.

When the Northers reach the eastern shore of the Philippines they deposit nearly all this accumulated moisture there. Consequently during the months of the Northeast Monsoon, say from October to February, the rainfall can be very heavy along the eastern coast of the Archipelago, amounting to a monthly mean of 400-500 mm. (16-20 inches). Tacloban, for example, in Leyte near the eastern coast, is quite unprotected and therefore gets abundant winter rainfall, as the American invaders found to their cost in 1944.

On the contrary the western coast will be very dry since the Northers arrive drained of their moisture. Thus Vigan, for example, on the northwest coast of Luzon, may have absolute drought for months at a time, and has an average monthly rainfall during the "*Nortes*" period of only 1/6-1/2 of an inch.

Manila occupies a middle position in regard to rainfall at this time, since it is not entirely shielded from moisture-laden Northers, especially when they approach it from the east. Luzon has not at this point so many mountain barriers to the east of Manila separating the city from the Pacific, and hence the *Nortes* do not so completely precipitate their moisture on the mountains.

Over the Pacific the Northers are usually attended by rather thick strato-cumulus cloud formations. Naturally, when the wind reaches the Philippine eastern shore these change to gray rain-making nimbus. But

thereafter in the central regions individual fair weather cumulus or dry-looking, hard strato-cumulus prevail, containing but little rain.

From what has been said it is clear that rainfall, except on the eastern coast, is spasmodic during the Northeast Monsoon. It causes scattered showers, a type of weather extremely common during many months of the year in the tropics, and very difficult to predict. It sometimes happens in Manila that rain falls in Ermita while the Escolta or Intramuros, a kilometer or two away, remains dry. It follows that forecasting exactly where showers will fall is pretty much guess-work and at the present stage of meteorology, it is hardly possible to be more definite than the much criticized and lampooned forecast: "Probable or scattered showers."

The Northeast Trade

The second big air stream playing a decisive role in Philippine weather and the most important one is the Northeast Trade. This originates in the cold North Pacific where a "high" or huge dome of heavy air is pressing out and driving its air masses towards warmer areas and lower pressures. The Northeast Trade, by the time it reaches the Philippines, has been twisted by the earth's rotation to move in a westerly direction. However, its exact direction varies. It may come from the northeast from November to February and then it fuses amicably with the "*Nortes*" from which under these circumstances it differs little in temperature and humidity. From this position it swings to become an east northeast, east, east southeast or southeast wind. The latter direction is especially noticeable in March and April. In fact in May the Trade may come from the south and even at times from a southwesterly direction. In this latter case it is easy to confuse the Trade with the Southwest Monsoon, the third big air stream, to be discussed below.

This Northeast Trade may be active in part or in all of the Philippines almost any time of the year. Nevertheless it is dominant and unfused with other air masses from the latter part of February, through March and April and even into May. At its source the Trade is quite brisk, but as a rule over the islands it is rather mild.

Although the Northeast Trade reaches the Philippines after traversing vast stretches of ocean, in its pure manifestation, namely, when unfused with other streams, it is the dryest of all Philippine air streams. It is the "fair weather" wind. It is not only dry aloft, above the inversion (as described in the case of the Northeast Monsoon), but it is comparatively dry even below the inversion where the air spreads and sinks, thus becoming warmer and effectively dryer. As long as the inversion endures, it is surprising how warm the weather can remain without producing thunderstorms. But when April arrives and the inversion is lost due to the disturbing impact of the Southwest Monsoon, upward convection is increased with consequent precipitation and instability aloft. These phenomena indicate that something more than heat is needed to produce electrical storms. These other factors may be loss of inversion due to the confluence of other disturbing air currents, or forceful lifting over mountains, and especially frontal conditions, to be discussed below. But all of these indicate that, in addition to the heat, some other physical upsetting of the equilibrium is also required.

When the unmixed Trade is blowing, fair weather clouds prevail, especially small fragmentary or flat cumulus. As the inversion disappears cumulus congestus and cumulo-nimbus will also put in their appearance. But in any case the rainfall in the Trade is usually not abundant.

The Northeast Trade is the Philippines' warmest wind. Even in February the thermometer will at times register over 90° Fahrenheit under its influence,

while the clear skies and unimpeded sunshine add to the heat. However, except in enclosed areas like the Cagayan Valley in northern Luzon, the hundred mark is rarely reached, due on the one hand to the equalizing influence of the moderate temperature of the surrounding Pacific Ocean and the China Sea, and on the other to the movement in many parts of the Islands of brisk land and sea breezes. Nevertheless, the heat of the Trade is more oppressive than comparable temperatures in other lands because its humidity (though not high by Philippine standards) is still considerable.

The Southwest Monsoon

The third great air mass which affects the Philippines is called the Southwest Monsoon. This wind is by no means as constant in the Philippines as it is in India. In fact the Philippines are only on the edge of the true Indian Monsoon which in these longitudes must contend with two other air streams that enter the Philippines from the same sector of the compass, namely, the Northeast Trade (which, as just noted, often blows from a southeast, south, and even southwest direction) and the Southeast Trade. If, as generally happens due to a turning force to the right caused by the earth's rotation, the Southeast Trade upon crossing the equator is diverted into a southwest wind, its characteristics approach those of the Indian Monsoon, and what is commonly known in Philippine meteorology as the Southwest Monsoon is really either or both of these streams. It is of this hybrid that the present study uses the term.

The Southwest Monsoon first makes its appearance in April or May in the southwest of the Archipelago. It then gradually advances further and further north into the Islands until by August it dominates the whole Philippines and a considerable distance beyond northward. About September the *Nortes* begin to build up, blowing, as noted above, from the

northeast. Increasingly during the months following September the Southwest Monsoon is pushed slowly south, until by the end of November or December it is compelled to stay below the equator.

The mean temperature of the Southwest Monsoon is between that of the warm Northeast Trade and the chill Northeast Monsoon, namely, about 25-26 C. (77 to 80 F.). One of the main reasons for this comparatively low temperature is the prevalent cloudiness, a very fortunate circumstance, since it helps to cool what would otherwise be the hottest months of the year.

The Southwest Monsoon is by far the most humid of Philippine air currents and this explains its beneficent cloudiness. Its high moisture content is not confined, as with the Northers and Northeast Trade, to the first two kilometers by an inversion ceiling but penetrates at least to the fourth and fifth kilometers.

The usual explanation given to account for this abundant moisture is the wind's equatorial origin. But this explanation is not satisfactory. Right at the equator another wind, the Southeast Trade, can be as dry and clear as the Northeast Trade in the Philippines in March. Recent studies point to convergence as the more potent factor in creating the high moisture content. On crossing the equator convergence occurs with the Southeast Trade, and masses of air are forced up by the collision of the two streams. This breaks the inversion ceiling and facilitates convectional ascent of moisture up to at least four kilometers. During the wet season the Philippine region is a veritable melting pot of converging winds, perhaps the best and largest example in the world. It is not remarkable therefore that the prevalent clouds during the period are nimbus or rain clouds.

Because of the aforementioned factors it is easily understood why the Southwest Monsoon produces copious rainfall. This is especially true when on occasion it breaks into violent squalls as it is rapidly

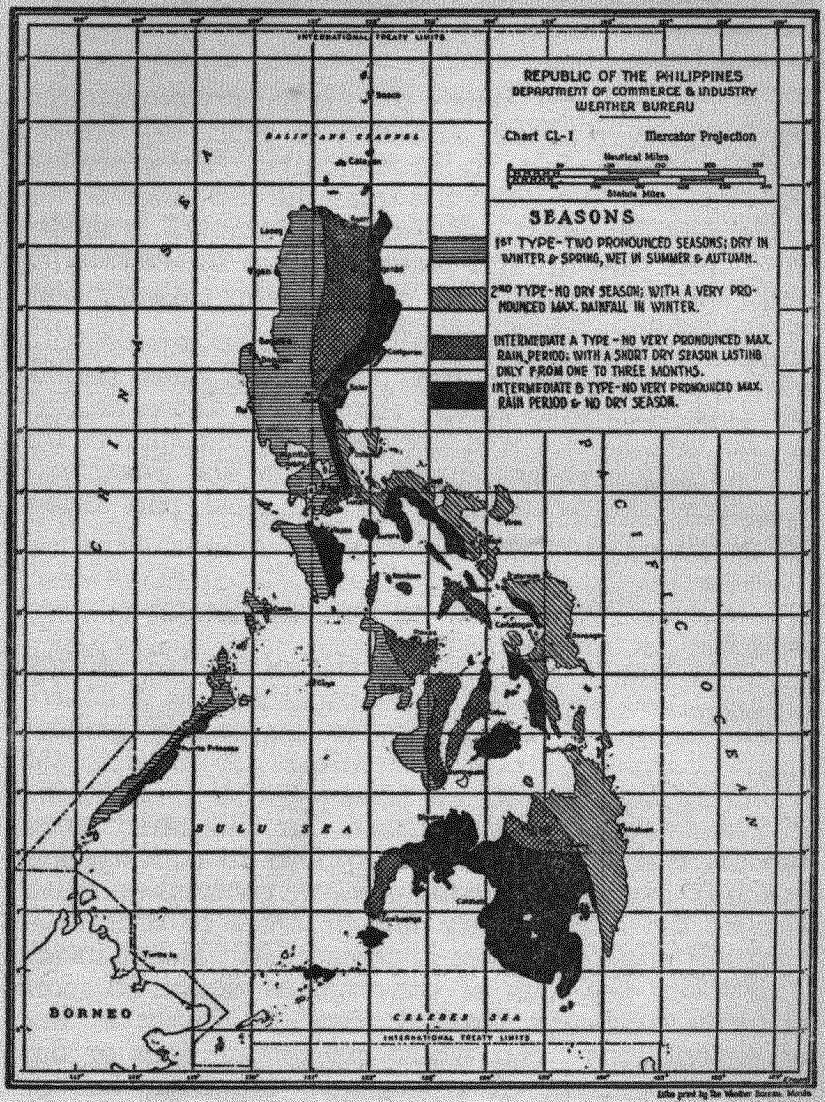
drawn towards a low, created by a typhoon to the north, northeast or east. In this rush of air towards the low pressure of the typhoon convergence is increased, and upward convection is also increased with greater resulting precipitation. In fact, often the first indication of a distant typhoon in the Pacific may be the "hitting up" of the speed of the Southwest Monsoon through the Islands.

As the Southwest Monsoon strikes the western shorelines first, it is they that get the most rain. The mean monthly rainfall for western Luzon during this season amounts to 800-1,000 mm. (32-40 in.). On the other hand the eastern shores and Mindanao, except when they are under the influence of a nearby typhoon, get much less rain during the Southwest Monsoon. During August, however, when the Islands are under the monopoly of the Southwest Monsoon, either because the point of convergence with the *Nortes* is still far to the north, or because the Southeast Trade is reaching the Islands unfused with the Indian Ocean Monsoon, the Philippines may get spells of fine clear weather. In other words, in each case convergence has not taken place over the islands, either with the Northers or with the Indian Ocean Westerlies.

In summary then there are four Philippine climatological types:

(a) *First Type:* Where there are two pronounced seasons, one dry from November to April, the other wet from June to October. The dryness is due to the fact that the Northers are washed out before they reach these regions; the wetness is due to the impact of the Southwest Monsoon. Vigan, Ilocos Sur, for example, would fall into this category.

(b) *Second Type:* Where there is no dry season but a very pronounced maximum rain from November to February. These rains are caused by the moisture moisture content. There is no pronounced dry season laden Northers first meeting land masses to tap their



FOUR TYPES OF PHILIPPINE CLIMATE
(Courtesy of the Philippine Weather Bureau)

because thunderstorms occur in March, April and May, and later typhoon rains preclude excessive dryness. Tacloban, Leyte and Baler, Quezon, would be examples of this type.

(c) *Third Type:* Where there is no very pronounced maximum rain period, and only a short dry season lasting only from one to three months. These are the regions somewhat protected from the full onset of the Southwest Monsoon and thus their rainfall is moderate. But they are not protected from thunderstorms and typhoons. Cebu City falls into this classification.

(d) *Fourth Type:* Finally there are regions with no dry season and no very pronounced rainy period. Most of Mindanao except the eastern shore belongs to this group, since it is shielded from the rains of the *Nortes* and from the direct onset of the Southwest Monsoon. Moreover, it is for the most part below the usual track of the typhoons.

II. The Fronts or Frontal Zones

In speaking above of the rise of electric storms, mention was made of frontal conditions as a contributing factor. It remains now to say something about this important element of weather. A front is the meeting place of two air streams with temperature differences of notable contrast. In this strict sense the name cannot usually be applied to convergences in the tropics where the temperature contrast on either side of the discontinuity line or areas of contact is generally slight and even imperceptible. Hence in the Philippines the area of convergence would be more accurately called a "frontal zone" or simply a "line of discontinuity" (i.e. where one stream ends or discontinues and the other begins). However, for the sake of brevity the word "front" will be employed.

The first front to be considered is the Northers-Trade or Polar front, the meeting of the Northeast

Monsoon and Northeast Trade. In November the usual position of this front is just east of the Asiatic Continent, following a northeast-southwest line from Japan to Formosa through the Balintang Channel (just north of Luzon) onward to Indo-China.

The Northers move down the western side of the line, while the Northeast Trade striking into the *Nortes* from the east splits into two branches just above Formosa. One branch turns northeast moving opposite to the flow of the *Nortes;* the other turns southwest with the *Nortes.* It is this lower part of the front that affects the Philippines. However, if the front is stationary it causes little disturbance, for the two component winds, the Northers and the Northeast Trade reach the Islands almost from the same direction and over the same waters. The collision is therefore slight and since the difference in temperature and humidity is also inconsiderable the Polar front is very mild in its effects. The only effect in the Philippines under these circumstances is an increase of cloudiness and perhaps of rain along the already rainy eastern coast. However, north of the Philippines, in the latitude of Formosa and higher, the contrast in temperature between the still cold *Nortes* and the warmer Trade is greater with more air uplifting and consequent rain and other frontal characteristics, like fog, squalls, etc.

Moreover, even in the Philippines, if either component wind is more than usually strong and thus tends to override or undercut the other the result is felt in the weather. Thus if the Northers instead of joining peacefully with the Trade surge towards lower latitudes undercutting and lifting the Trade, the result will be an increase of rain mostly of the shower variety, but also with squalls along the surface front and thundershowers. If on the other hand the Trade instead of joining peacefully with the Northers rises and climbs over them, driving west or northwest, steady drizzles or even stronger rains will result. In each case the greater commotion drives air aloft where it is chilled

and, since cold air cannot hold as much water vapor as warm, it is forced to give up its moisture.

When the Polar front is in this first position, just east of the Asiatic coast, storms very often start on it in southeast China or near Formosa. Then due to the strong temperature contrasts both in water and air along the Asiatic Coast in the winter, the storms increase rapidly in severity travelling northeast along the front until they reach Japan and then move eastward towards the Aleutians. These storms do not much affect the Philippines because they usually start to the north of the Philippines. They may however disturb and step-up the action of the Northers to their west. These storms are not typhoons; on the other hand they seem to differ in origin from the usual transcontinental storms which sweep across Asia and Japan more directly from west to east.

Here it is best to explain *roughly* how a typhoon differs from other storms. The question is a mooted one technically, but in this paper we use "typhoon" to designate a storm in which the rotary winds are decidedly fast with rather slow forward motion of the center of the storm. In other storms the rotary motion is comparable with or even slower than the motion of the storm center.

Later, in December and January, the front between the Northers and the Northeast Trade may move east or southeast to rest its southern extremity around Guam. In this case the *Nortes* have free play in all the territory west of the line. But the favorite position of the front is a northeast-southwest line based in southern Mindanao. This means, as far as the Philippines are concerned, a consequent further increase in rainfall in eastern Mindanao, the only part of the Philippines near the front.

These are the common positions of the Polar front: it lies off Asia in its beginnings (e.g., Sept., Oct., Nov.) then moves east or southeast to a position off the east

coast of Luzon and into Mindanao, or even further east to Guam. But occasionally the line of the front may oscillate back and forth through southern Luzon, without however as a rule initiating any serious storms in this position, but only mild rains.

When the Northers push very far south, e.g., into Mindanao, they sometimes start to curve back towards the northwest. In this way they meet fresh Northers moving southwest along or near the Asiatic coast. This convergence establishes a new front which is little different in its effects from the Polar front just described. The temperature and humidity are closely similar (at least when the front is formed far south) and so cause little disturbance.

Another front is that caused by the meeting of the same Northers and the Southwest Monsoon but discussion of this will be postponed for the present until the subject of typhoons is discussed, with which this front is closely connected.

There is, as hinted above, also a front within the Southwest Monsoon itself which as taken here may be composed not of one but of two converging winds, the Southeast Trade and the Indian Ocean Monsoon. If such convergence actually takes place and they in turn are drawn toward a typhoon, the activity then induced may cause this front to become quite active with consequent squalls. It was along such a front that Mirador, Baguio City, Luzon, got the largest registered 24-hour rainful in the world, i.e., 45 inches, even though the center of the typhoon was at the time in Formosa.

The meeting of the Northeast Trade, which, as has been noted, continues to blow long after the *Nortes* have ceased, and the Southwest Monsoon creates another very important front, called the Equatorial Front.

The actual position of this front, though its mean location is near the equator (hence its name), can vary very much with different years. Nevertheless, some general observations can be made. About April the

weakening of the *Nortes* permits this front to move into the northern hemisphere. During April its favorite position is approximately north to south in the western or central China Sea, forming the eastern edge of the Indian Monsoon, namely, with the Southwest Monsoon to the west of the line and the Northeast Trade (now coming from the southeast or south) occupying the east and dominating the Philippines.

As the year advances the Equatorial front moves east across the Philippines traversing it for a time from north to south like a spine. After crossing Mindanao it assumes a northwest-southeast direction, with its southeast end based on the Marianas and the Carolines.

By July it is entirely east of the Philippines and by August its northern tip is as far north as the latitude of Shanghai. Then as the high pressure which originates the Northers builds up in Siberia and Manchuria, the Northers or the Northers and the Northeast Trade, by now coming in from the northeast again, push the Equatorial Front gradually south, usually meeting it on a northwest-southeast axis or even on a west-east. Finally by December the front is forced back across the equator to influence only the southern hemisphere until the following April.

In the north-south position of the front, the weather in the Philippines can vary considerably. Around April when the front is in the western or central China Sea, the Philippines are entirely in the Northeast Trade with very fine weather. There is little activity at the front and few storms start there, because the movement of the components is harmoniously south to north and humidity and temperature differences are slight.

But when the front goes directly across the Philippines as occurs in late May, then many thunderstorms occur. The Northeast Trade and Southwest Monsoon now mingle with the land and sea breezes, and oscillate back and forth with considerable disturbance and upward convection and consequent thunderstorms.

It is interesting to note that Padre Faura, founder of the Manila Observatory, as long ago as the 'seventies of the last century, noticed this *lucha* or struggle between air currents. In fact, he was decidedly ahead of his time in his ideas on air streams and the origin of storms at their conjunction. He even used the term *masa de aire*, air mass, a favorite term in modern meteorology.

When in June and July the Equatorial front takes a position east of but near the Philippines the weather becomes worse. The Islands are then directly in the Southwest Monsoon, with its four or five kilometers of moisture. The direction of the Trade has now changed to meet the Monsoon at an angle with consequent convergence and upward convection. The result is squally weather and heavy showers. This is especially true, even without typhoons, if pressure is low north of Luzon. This low creates a chimney towards which the Southwest Monsoon rushes, coursing violently through the Islands. The result of this condition is that type of squally weather known as the *colla*, strongly resembling true typhoon weather, and hence a constant worry for the forecaster.

The only other position of the front *through* the Philippines is the west-east position, usually found from September onward when the Northers and the Northeast Trade have begun to exercise their thrust. In general, the effects of the east-west position on weather are comparatively mild. There may be some rains, thunderstorms and mild squalls, but it is rare for a typhoon to arise on such a front. In fact no typhoon has ever been known to form in the Islands themselves, due largely to the deterrent effect of the greater friction on wind caused by rough land topography than by level water surfaces.

If, however, the axis of the front is west-east over the water near the Marianas or Carolines, or northwest-southeast from North Luzon to near Guam and

Yap or Palau, then conditions are ripe for the formation of typhoons.

III. Typhoons

No one knows with perfect precision all that goes to make a typhoon and to shape its course. Nevertheless, much of what has been said in the foregoing lines helps one to understand the formation of these familiar storms. The Northeast Monsoon (the Northers), the Northeast Trade and the Southwest Monsoon may be compared to great rivers of air. When rivers meet they do so with varying effects. If two parallel streams merge there is little disturbance; if one stream enters another at some angle it causes more commotion; if two streams meet at right angles or even head-on, as happens when an incoming tide meets the mouth of a stream, there is great turbulence. Moreover, the reaction in each meeting will depend also on the speed with which the streams meet.

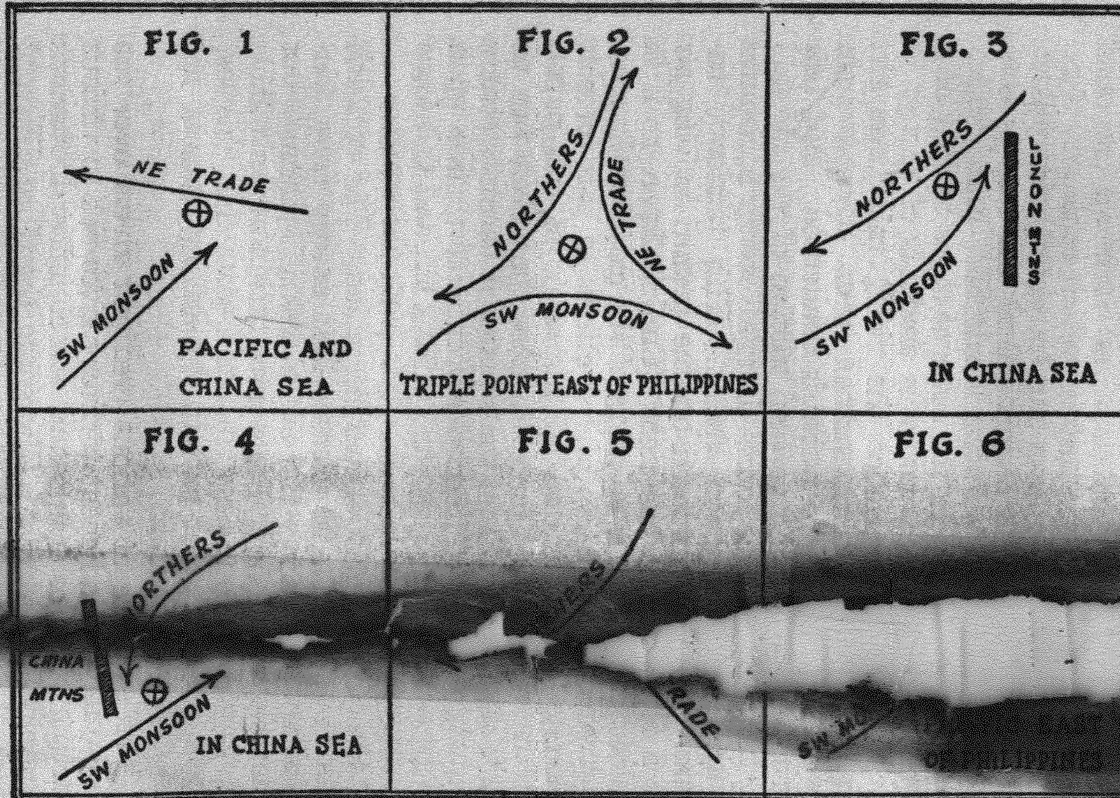
But this parallel breaks down in several important points. First of all, the air rivers are not contained within banks but shift their courses for various reasons, and can moreover be pushed out of course not only horizontally but vertically by the impact of other air-rivers. Secondly, the air-rivers differ in humidity and temperature and consequently the meteorological reaction at the point of collision will be seriously affected by these factors also. Finally these air streams may travel at different levels and so may pass under or over each other.

The convergence or collision of two of these air-streams causes weather trouble. The Southwest Monsoon and the Northeast Trade can be taken as an example. After its passage over the equator the Southwest Monsoon is very humid at least to the height of four kilometers; the Trade somewhat humid for a kilometer or two near the surface but very dry above that. At the Philippines the temperatures of the two streams

ar[illegible]nt at the surface. When these two str[illegible]me of the air is naturally piled up and [illegible] cooler higher regions. Cool air cannot [illegible]ch moisture as warm air can, and so the [illegible] the surface, which cools and rises, gets [illegible]ds form and torrential rains follow, gener[illegible]reds of miles along the zone of convergence. But that is not all. Water vapor when [illegible] from the state of a gas to that of a liquid [illegible]ses enormous amounts of energy in the for[illegible]. Hence the rising rain-laden air, heated [illegible] surroundings, must ascend even higher, [illegible]more water is condensed. But this accounts [illegible] the vertical motion of the air and the rain[illegible]nce comes the great rotary horizontal motion [illegible] typhoon vortex? This tendency towards rot[illegible] imposed on the inward moving air by a forc[illegible]wards the right (Coriolis force, as it is called) ca[illegible]d by the rotation of the earth on its axis. A complet[illegible]xplanation of the effects of this force is entirely too [illegible]mplicated for the scope of this paper. At the equ[illegible]r this force vanishes, but even two or three degre[illegible]way from the equator it becomes strong enough gra[illegible]ally to impress a rotational motion upon all air sucked in towards the uprising air, and this force increases the[illegible]ther the distance from the equator.

One other element must be added. The collision gets the air aloft and releases heat energy from condensing wa[illegible] vapor, the earth sets it spinning, but what moves [illegible] along? From information now available from upper air soundings, it would seem that this last factor is due in great part to the driving force of the prevailing winds aloft.

The existence of various great air rivers over the Philippines and adjacent territory gives rise to various meeting places or fronts and consequently to various centers of disturbance. There are therefore different types of typhoons in the Philippines stemming from different sources, pursuing different paths and showing



Some Possible Air Stream Combinations in Typhoon Formation

different characteristics. It is tempting to treat all typhoons and hurricanes as alike but this would be contrary to fact. Rather, there are various types, and to go by mere generalizations and statistical averages in their regard is a dangerous procedure.

There are four principal types of typhoons in the Philippines varying according to the originating front. This author has never found a typhoon in the Philippines which with certainty originated within a homogeneous air mass and not on a front.

The first type of typhoon is that which originates on the front created by the Northeast Trade and the Southwest Monsoon, and can therefore be simply designated the Trade-Southwest Monsoon type. (Fig. 1) It prevails in the absence of the Northers, therefore roughly from April to August. The Southwest Monsoon coming in from the south and southwest occupies a large sector of the typhoon mainly southwest of the center. The Trade converging from the southeast and east occupies the rest. The disturbance at their convergence is not due to a difference in temperature between the two streams at the surface, making one air stream denser than the other and thus pushing it under the other, but to other causes already mentioned.

The path of this typhoon type if it remains "pure," due to the dominant influence on it of the Northeast Trade aloft is usually straight west northwest or northwest, i. e. from the Pacific into China. However, later in the season the Northers may enter into this storm, changing not only the type but the path as well.

The second type of typhoon arises from a convergence (towards a point) of all three air streams, and hence can be called the Triple Point type. (Fig. 2) With the building up of the Northers from August on, typhoons arise in which all three air masses, the Northers, the Northeast Trade and the Southwest Monsoon participate. In this combination the Trade roughly feeds the east sector of the storm, the Northers the northwest and the Southwest Monsoon the southwest.

A typhoon of this type will commonly (but with many exceptions) move first west northwest, then north, then northeast towards the Aleutians. As the season progresses and the *Nortes* get stronger, the recurve towards the northeast starts further and further south in latitude.

At the very beginning and end of the typhoon season, hence in April, November and December, there occurs a class of small but fast typhoons hitting the southeast shores of the Philippines. Precisely because they are small and fast, they are quite difficult to forecast in time to give sufficient warning. They probably originate as Triple Point typhoons near the equator, but very soon lose their Southwest Monsoon sector.

With the more usual larger Triple Point typhoons, the Northers do not start to eliminate the Southwest Monsoon until the start of the northeast recurve. This is probably made possible by the increasing temperature difference as the storms move further north. The colder northern air is denser, and hence undercuts the other air and eliminates it gradually from the storm, starting from the surface upward. By the time the storm has reached the latitude of Japan it changes its nature usually to that of an ordinary temperate zone cyclone, i. e. the continuance of the storm is now due mainly to the interaction of cold and warm air and not to a chimney effect as in typhoons.

Not all Triple Point typhoons start as such. A storm may start as a Trade-Southwest Monsoon Type and travel west northwest until it meets the Northers which then enter into its composition and give it the characteristic of a Triple Point type.

Because of the involvement of three contending air masses and the variations possible in all of them, the path of this type is by far the most irregular of all. The Northers are the most consistent disturbers. Due to their varying strength at various times their influence can be most disconcerting to the forecaster. For example at the northeast recurve stage they can

drive the typhoon first south before them and then ultimately bring about a complete loop or circle. Or the Northers can meet a Trade-Southwest Monsoon typhoon in its west northwest course towards China and force it to take a west southwest or southwest direction. This type of typhoon is therefore a constant source of worry for the forecaster and must be carefully watched. Long range forecasting is at present well nigh impossible.

A third type of less practical interest for the Philippines is born on the Northers-Southwest Monsoon front. (Fig. 3 & 4) These occur in the China Sea where the mountains to the east prevent the intervention of the Trade. This type of typhoon is usually small and may go northeast (if the Monsoon prevails over the Northers) or southwest (if the Northers prevail over the Monsoon).

A fourth type is formed by the convergence of the Northers and the Northeast Trade. (Fig. 5) The Trade is involved in the southeast part of the storm and the Northers in the rest. The cause of this typhoon seems to be an unusual spurt of strength in the Trade, what Dr. Fassig calls a "flood" of the Trade. This challenges the domination of the *Nortes* and pushes them westward. The path of this type is like that of the Triple Point, first west northwest or northwest, then north and finally northeast. But since the unpredictable Northers are a component, the path may in fact be very irregular.

In the foregoing classification some hint has been given concerning the places of origin of these various types of typhoons. Already it was noted that the China Sea can be the scene of a small typhoon when the Northers meet the Monsoon there without the intervention of the Trade. Then the front often gets very strong especially when one of the air streams is jammed against the mountain ranges either of Northwest Luzon or Southeast Indo-China. (Figs. 3 & 4)

Also in the same China Sea in those areas where

the Trade can sweep in from the east it will converge upon the Southwest Monsoon travelling north. (Fig. 1) As a result of this convergence a typhoon often springs up between Northern Luzon and North Indo-China, moving as a rule west northwest. These typhoons are usually small in diameter but they can be quite destructive.

Another favorite hatching area for typhoons is the Pacific Ocean between Guam and the Philippines. If the Trade is blowing northwest out of the Pacific towards the east coast of the Philippines, the Southwest Monsoon will often collide with it in this ocean tract. In this case the Southwest Monsoon splits into two branches, one of which slips southeast along the front, the other moves with the Trade northwest. (Fig. 6) At this juncture of the two air streams a typhoon may arise.

Moreover if the Northers-Trade front meets the Southwest Monsoon in the Pacific a Triple Point typhoon will often arise at the junction. (Fig. 2) As the typhoon proceeds north the Southwest Monsoon may be eliminated from the storm and be forced south. If the Trade also follows south then the process is repeated and another Triple Point type is formed.

Another type of typhoon that forms in the Pacific between Guam and the Philippines is independent of the Southwest Monsoon. It arises when the Northeast Trade moves westward jostling the *Nortes* and setting up characteristic convection to inaugurate the uprush that is twisted into a typhoon by the spinning earth. (Fig. 5)

Still further east and southeast typhoons arise in the Caroline-Marianas sector. However, they are less well known than the others because data are scarce. They seem to arise when a tongue of west wind from the Indian Ocean penetrates further east than usual, invading the territory of the Northern and Southern Hemisphere Trades. Still others seem to start in the Caroline-Marianas sector when the Southeast Trade of

the southern hemisphere, on crossing the equator and being diverted from a southeast to a southwest wind, joins against the Northern Trade.

SUMMARY

In the foregoing pages the main factors of Philippine weather have been discussed. Three great air masses, or winds, dominate the Philippine skies, the Northeast Monsoon originating in Siberia and Manchuria, the Northeast Trade originating in the North Pacific, and the Southwest Monsoon formed by a conjunction of the Indian Ocean Westerlies (or Monsoon) and the Southeast Trade at the Equator.

These three winds meet and mingle in various ways, differing with the time of the year and other factors. The meeting constitutes a frontal zone, called in this paper simply a front. These fronts are the scene of weather changes, because the differences in temperature, humidity and direction give rise to upward convection with consequent clouds, rain and wind.

A still more important consequence of the fronts is the typhoon. There are four types of typhoons originating from various combinations of convergent winds. When the air, inrushing to replace that lifted by convergence and heated by the condensation of water vapor, is spun by the earth's rotation, a typhoon is formed.

If there is much in the description of Philippine weather which remains mysterious to the reader this is due first to the fact that complete explanations would require a space not available here and carry the article into scientific technicalities beyond the scope of this paper and secondly it is due to the fact that not a little still remains mysterious even to the meteorologist.