ZI-KA-WEI OBSERVATORY

NEAR SHANGHAI, CHINA

HARVARD
BLUE HILL
Meteorological Observatory
MILTON, MASS. U.S.A.
UNIVERSITY

THE TYPHOONS

OF THE CHINESE SEAS

IN THE YEAR

1885

BY THE

R. F. MARC DECHEVRENS S. J.

DIRECTOR OF THE OBSERVATORY.

ZI-KA-WEI

PRINTED AT THE CATHOLIC MISSION'S PRESS, TOU-SE-WE.

1885.

KELLY & WALSH — Shanghai.

National Oceanic and Atmospheric Administration

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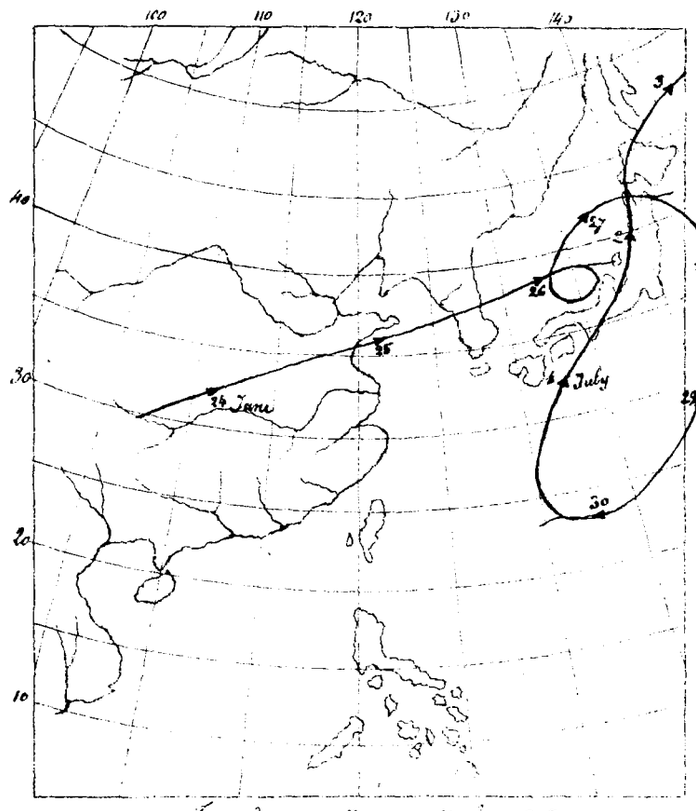
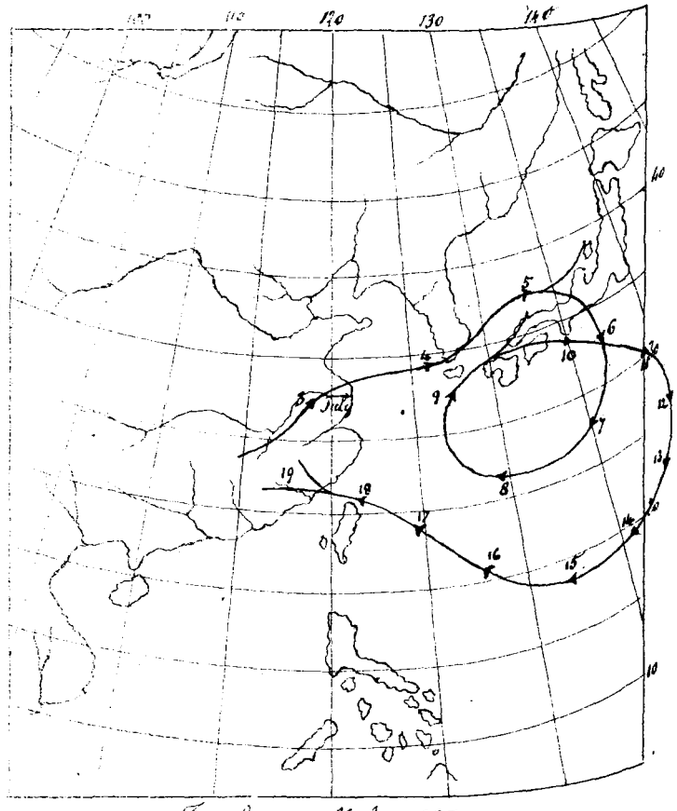


Typhoon: June & July 1885



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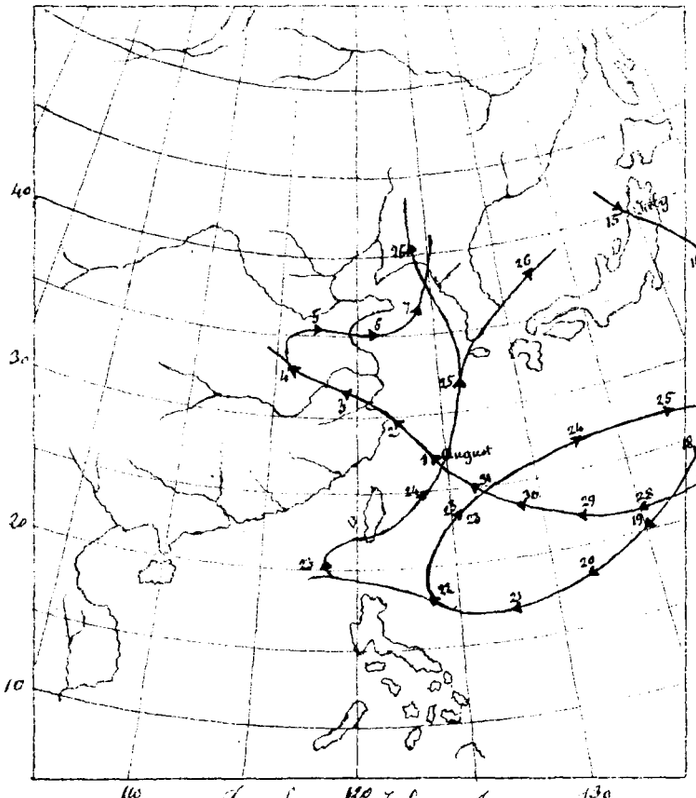
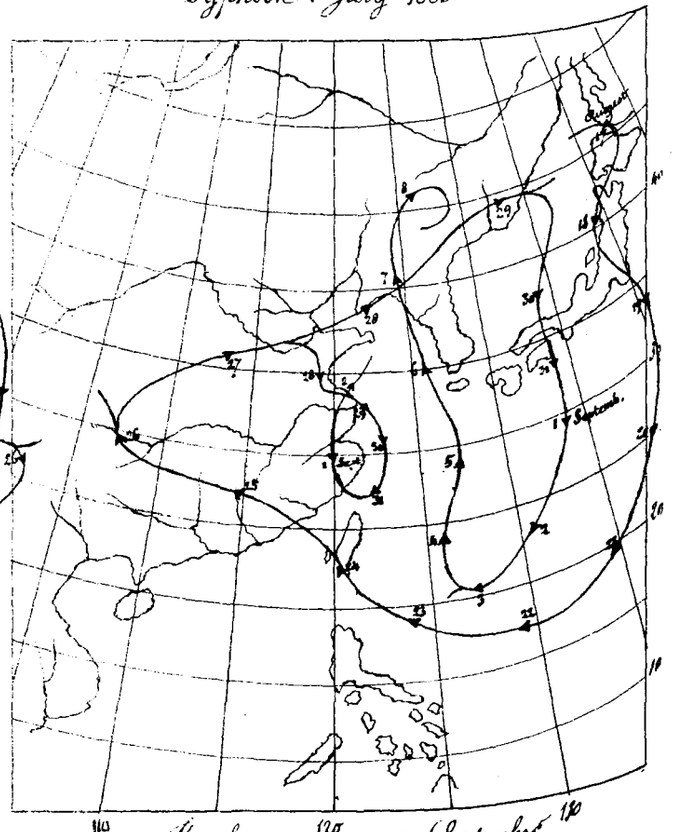
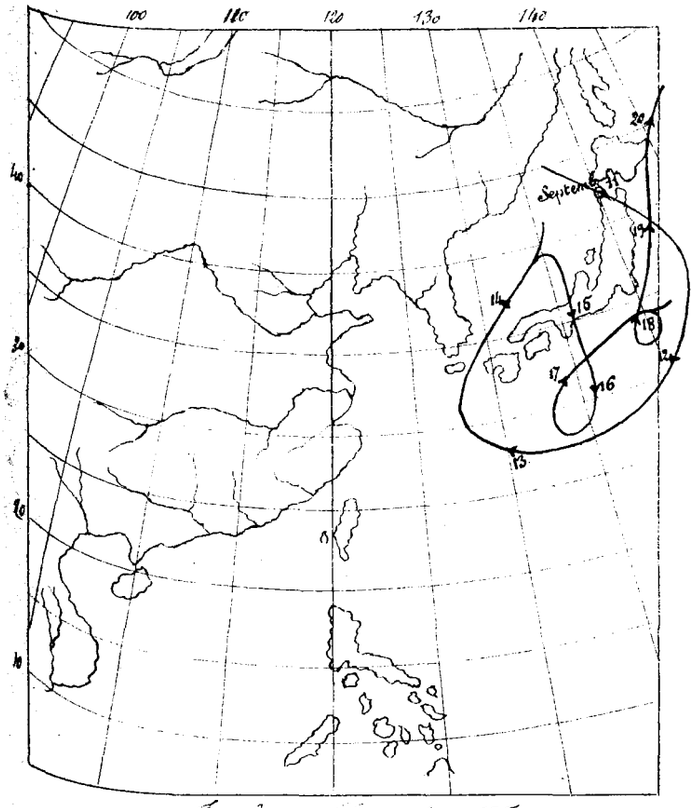


Typhoons: July & August



Typhoons: August & September



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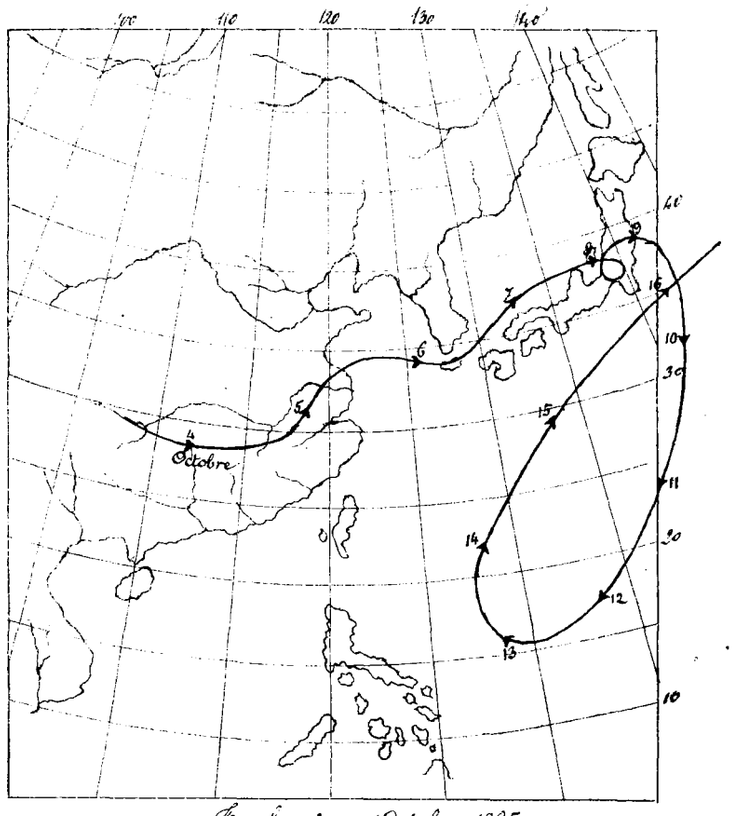
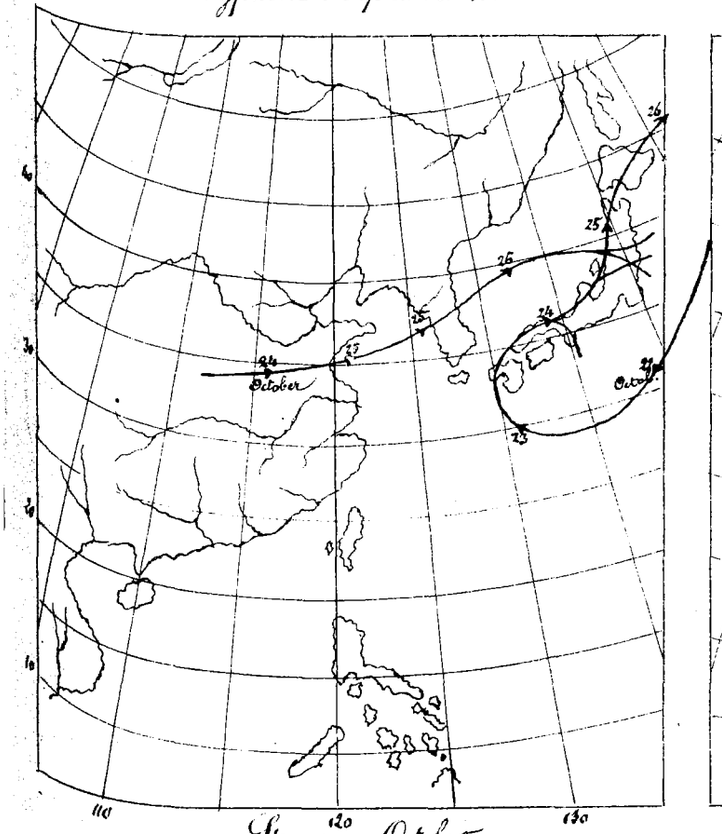
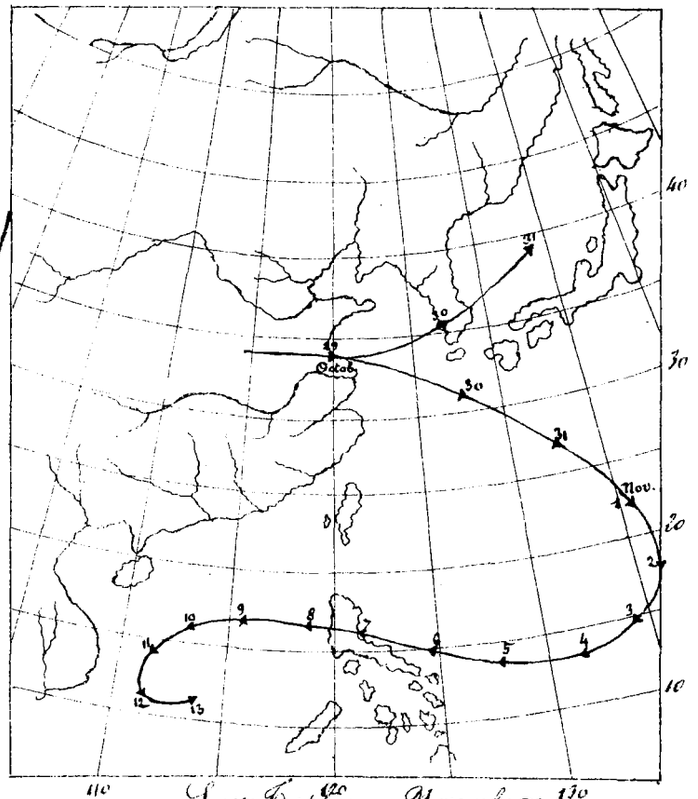


Typhoon : October 1885



Storms on October



Last Typhoon : November

TYPHOONS

IN THE YEAR 1885

The Typhoons of August 24th and September 5th 1885.

I. — FROM WHAT PLACE COMING?

On the 24th of August, about noon, a violent Typhoon came up to the southernmost point of Formosa. After running for some time along the foot of the high mountain chain which forms, as it were, the back-bone of that great island, it shot obliquely across the canal, leaving the Pescadores to the left and the Ockseu light-house to the right. It reached the continent about latit. 25° and made away to the WNW, ultimately to turn northward after crossing the Yang-tze-kiang beyond Ichang.

Where had the Typhoon come from when it touched Formosa? — if from the South-east as it undoubtedly had, had it sprung up in that region, or must we look for its origin in other quarters?

That a Typhoon may appear to the South-east of Luzon, near the eastern coast of Mindanao, for instance, is a well ascertained indubitable fact. But that it should have first originated in such low latitudes has never been proved; nor have any observations either been brought forth to support the assertion that such Typhoons had come from the Caroline islands, as from their birth place.

Careful investigations have led me to abandon such ungrounded opinions and to adopt a view which may appear somewhat strange, but which in fact agrees with the erratic character of the Typhoons and, generally speaking, of the atmospheric depressions proper to these regions. Several of the whirlwinds of 1882, 1883 and 1884 seem to have had no other origin than a storm or even a typhoon that left Japan and made for the South. The summer of 1885 offers a curious instance of this kind which I purpose studying at this point of view. I shall, as far as possible, follow the typhoon step by step from August 17th and not leave it till September 9th, after bringing it back to its starting point.

On the 18th and 19th of August, there was an anticyclone (area of high pressures) occupying Luzon. Wind at Manila: SW pretty strong on the 18th; W and WSW light on the 19th. This anticyclone also stretched over the China Sea and moved westward, for on the 19th and 20th we find high

pressures on the southern coast of China and so far as the bottom of the Gulf of Tonquin (Pakhoi). It follows that the winds blowing at Manila between SW and W were divergent with regard to the centre of the anticyclone, as might have been expected, and convergent with regard to the cyclone or atmospheric depression producing those high pressures. This then is a first circumstance inviting us to seek the centre of the coming typhoon in the North-East, not in the South-East, of Luzon.

Similar facts were observed at the South Cape of Formosa, where a meteorological station has been established with a new light-house, in 1883. The anticylone appeared here a little earlier than at Manila, which last station, we may observe, is about 500 miles to the South of the South Cape of Formosa. The barometer naturally began to sink at the northern station before it did so at the southern; which circumstance again justifies my previous assertion that the typhoon destined to enter the Formosa channel on the 24th was to be looked for rather in the North-East than in the South-East of Formosa and Luzon. It is interesting however to see all the particulars of this in the observations made at the two stations.

	South Cape of Formosa Barometer		Manila (Luzon) Barometer	
	9 a.m.	3 p.m.	10 a.m.	4 p.m.
	mm	mm	mm	mm
Aug. 17	758.4	758.7	760.2	758.9
18	60.7	60.0	61.0	58.7
19	60.7	59.4	61.5	58.7
20	58.9	57.7	60.5	57.4
21	57.9	56.9	58.9	55.9
22	55.9	54.6	56.1	52.6
23	50.6	48.0	51.6	51.8
24	34.5	37.6	53.3	53.9

No correction has been made to the observations of the South Cape station, whose altitude is about 70 metres; but this does not affect the variations, with which alone we are now concerned. Herewith a table of these variations.

	South Cape of Formosa Variations of the barom.		Manila. Luzon Variations of the barom.	
	9 a.m.	3 p.m.	10 a.m.	4 p.m.
	mm	mm	mm	mm
From. the 17th to the 18th	2.3	1.3	0.8	—0.2
18 — 19	0.0	— 0.6	0.5	0.0
19 — 20	— 1.8	— 1.7	—1.0	—1.3
20 — 21	— 1.0	— 0.8	—1.6	—1.5
21 — 22	— 2.0	— 2.2	—2.8	—3.3
22 — 23	— 5.3	— 6.6	—4.5	—0.8
23 — 24	—16.1	—10.4	1.7	2.1

Thus it is clear — 1° that the high pressures, forerunners of the typhoon, descended from Formosa to Luzon, from the 18th to the 19th; 2° that in the afternoon of the 19th, the barometer began to sink at the South Cape, while it kept stationary at Manila. We may also see that the fall was considerable on Formosa between the 19th and 20th, while between the 20th and 21st and particularly between the 21st and 22nd it was more rapid at Manila; and lastly that between the 22d and 23rd and between the 23rd and 24th if was more marked on Formosa again.

Let these different variations be compared with the phenomena which must, for the two stations, result from the course I have given to the typhoon on the annexed map.

On the 19th, noon, the centre of the Typhoon must have been about 1100 miles from the South Cape of Formosa and 1410 miles from Manila; the high pressures had already left Formosa and made

for Luzon and the China Sea; on the 19th and 20th the track bent somewhat to the South-west, which caused the centre of the Typhoon to stand nearer to Formosa than to Luzon: hence a falling of the barometer, particularly at Formosa; on the 21st and 22nd the typhoon would seem to have turned definitively to SW and W, to make straight for Luzon (further falling of the barometer at Manila), but, in the evening of the 22nd and still more on the 23rd, the track continued to bend and Formosa was now certainly the aim of the typhoon (barometer falling more and more on Formosa, while it was rising on Luzon). — Thus is every circumstance easily explained in the supposition that the depression came from the North-east.

But it may perhaps be objected, does this hypothesis agree with the observations made in Japan? — for such an important depression could not pass imperceived in that archipelago situated to the North-east of Formosa.

Here the investigation and discussion will be neiher long nor difficult. The *Tridaily weathermaps* issued by the Imperial Observatory of Tokio, give us a graphic representation of the variations of the atmospheric pressure and of the wind at 6 a.m., 2 and 9 p.m. for twenty-five meteorological stations scattered all over the archipelago, and show us palpably the relative situation of the areas of high and low pressures; if we add the observations made at Wladivostock, on the western coast of the Japan Sea, at Fusan on the Korean coast in the Strait of Korea, and at our stations of the North of China, all which observations may help to understand the various atmospheric movements registered in Japan, we shall have the best chance of arriving at the truth.

Now the following is the upshot of this mass of information.

On August 19th, while the barometer was at its highest on Formosa, it was low all over the southern part of Japan. A depression had come down from the North of the archipelago, following a winding track, as may be seen on the annexed map, and, about 6 a.m. on the 19th, its centre lay off Nippon, to the South of Tokio. If, notwithstanding its proximity, the winds were light on the coast and inland, it is because there was at the same time another depression spread over the South of the Japan Sea and tending to raise opposite winds. Besides, the former depression, at that moment, was far from forming an important whirlwind, having lost much of its energy by its passage across the archipelago and by the low pressures it had left behind. But let it only take to the offing in its southward course: it will soon recruit its strength, and it was undoubtedly its influence which on the 21st caused the wind to blow from N and from E on the southern coast of Japan, in spite of the western depression which had not yet made away. The easterly wind blowing over Japan on the 22nd is the counterpart of the strong westerly wind (force 8) that was blowing at the same time at Manila: the Typhoon was now fully formed.

In fact, it was truly a typhoon that on this very day was encountered near the Marian Islands by the British barque "*Mount Lebanon*" Capt. C. H. Nelson, sailing from Honolulu to Hongkong. The following is the report given by the Hongkong papers: «Left Honolulu for Hongkong on the 15th July «and had very fine and pleasant weather until passing the Marian Islands, in lat. 15°.29 N. long. 128°32 E. «Then, on the 22nd August, encountered a severe typhoon, accompanied with violent thunder and «lightning and torrents of rain, with terrific squalls at intervals. The lowest reading of the barometer «was 742.2mm. A severe gale continued to blow from 2 p.m. on the 22nd. until 6 a.m. on the 23rd. The «typhoon commenced from NNW., the centre then bearing ENE from the ship and travelled towards the «South through West. About 10 a.m. on the 23rd. got out of the track of the Typhoon».

Though very few meteorological particulars are to be found in this report, however it confirms my opinion about the origin of the Typhoon: the Captain showing it to come not from SE. but from NE.

It would undoubtedly be a matter of great interest to have some observations more on the long passage from Japan to Luzon. Wanting such, we must do the best we can with those made at a distance that have come to our hands and, since they all point to the same conclusions, we can supply by induction what is wanting and lay out the track of the typhoon almost to a certainty.

We then find an atmospheric whirlwind, first descending from latit. 46° to 18°, that is from Japan towards the Philippines, and afterwards running from SE to NW across a space of about 24° longit.

Now if I am wrong in my explanation of the facts, let the flaw in my deductions be pointed out But I hold as a principle that on many points the science of meteorology is properly in making, and consider the question of storms as being an open question. Let us therefore follow our Typhoon as closely as possible, and we shall logically infer that where it has passed others had passed before and others will pass hereafter; which conclusion will be an acquisition for Science.

II. — THE TYPHOON IN THE FORMOSA STRAIT.

At the South Cape the storm was of short duration. At 6 a.m. on the 24th, the wind, which had just turned to NW, was hardly stronger than force 5; and yet already at 9 a.m. the barometer had fallen to 730.0^{mm} (reduced to sea-level); wind WNW force 9. — At noon, barom. 733.3^{mm}; wind WNW, force 10. The passage of the centre of the Typhoon had then taken place between these two observations. The fall of the barometer since the 19th midn. had been of 27.0^{mm}. At 6 p.m. the wind blew from SW (force 9) and at midn. from SSW (force 7). The track then seems to have run between South Cape and the southernmost spurs of the central mountain chain of the island. Thus the Typhoon, instead of following off the Cape an easy unobstructed course, came to strike against the high mountains and seek a passage at their foot beyond Tai-wan-fu, a distance of nearly a hundred miles. This circumstance, though strange is not uncommon, and we had often noticed it in typhoons of the preceding years.

What may be the reason of this curious phenomenon? It may perhaps be sought for in the rarefaction of the air on the western slope of that high chain the central summit of which attains a height of 4000^{m}., an attraction would then be exerted on the whirlwinds coming from the South-east and striking with their north-easterly curents the eastern slope which faces open sea; we observe however that the splitting of the depression into two separate whirlwinds is frequently the result of that course of the Typhoon.

The centre of the Typhoon passed to the East of Takao and of Tai-wan-fu capital of the island. The barometric minima were observed: at Takao, 735.0^{mm} at 3^{h} 15^{m} p.m., wind WNW (force 11); at Tai-wan-fu, 734.6^{mm} about 4^{h} 30^{m} p.m., wind NNW equally strong. It was with the WSW winds which followed on the passage of the centre that the storm reached its worst; — force of wind, 12; diluvial rain, 216^{mm} rainfall at Takao on the 24th.

With regard to the winds at Takao, we may observe that, on the 19th noon, it began to blow steadily from WNW (force 4-7), and that the wind only began to turn to N through NW before the 23rd. The situation of that part with regard to the mountain chain of Formosa being taken into account,

we see that those persistent winds from WNW which were not experienced at the South Cape, blew straight to the offing between the southernmost spurs of the central chain and the group of high hills (600-700^{m}) which form the South Cape of the island. It was through this pass that the Typhoon rushed, as though called by the strong winds which bore towards it.

The Pescadores were passed at 6 p.m. — barom. 732.0^{mm}, wind W (force 10); on the 25th midn. turned to SW (force 9); 6 a.m. settled SSE (force 7).

The next light-house up the canal is that of Ockseu, situated by 25° latit. and 119° longit. Here the passage of the Typhoon is marked, not any more by westerly but by easterly winds, an indisputable proof that the centre had not passed the latitude of the light-house. The barometric minimum marking the passage of the centre within the shortest distance of the light-house was observed on the 24th, 9 p.m., 730.5^{mm}; wind NNE (force 10); veered in the same night to NE, E and SE (force 7); on the 25th to S (force 7-8).

These observations of Ockseu show us the Typhoon traversing the canal obliquely to reach the coast of China and take to the continent.

The Dodd Island light-house stands at the entrance of the port of Amoy : it is the last point near the track that may help us to determine its direction at the moment when the Typhoon was about to leave the canal. At Dodd Island the wind blew from W, and the track left Amoy to the South. The barometric minimum, 732.3^{mm}, occurred on the 25th, 2 a.m.; wind WSW (force 7); it had been blowing from NW (force 8) on the preceding evening.

Thus on the 24th about 10 or 11 a.m. the Typhoon was below the South Cape light-house, while on the 25th 2 a.m. it left the channel above Amoy : the distance of 193 miles between these two points had been run over in 15½ hours with an average speed of 12.5 miles an hour; the velocity between Taiwan-fu and the coast of China seems to have been of about 14.5 miles.

At all the stations of the channel the fall of the barometer since the 19th, date of the passage of the anticyclone mentioned above, was of 27^{mm}-29^{mm}.

The greatest fall took place at Tamsui, in the North of Formosa, at the entrance of the channel. Here on the 24th, 5 p.m. the barometer sank to 728^{mm}, this being a fall of 31^{mm} since the evening of the 18th. The barometer at the Tamsui station is a mercurial barometer.

We must notice some particulars of the variation of the wind at Tamsui, which are evidently due to the situation of that town to the North of the central chain of Formosa. From the 22nd, noon, to the morning of the 25th, that is to say, for sixty five hours, the wind kept steady from NE; light at first (force 2), it freshened rapidly (force 5 and 6 on the 23rd); all the 24th there blew a violent storm (force 10-11), moderating somewhat however (force 8) in the afternoon, at the time when the mountain chain intervened between the port and the centre of the Typhoon. During the night the storm increased again and blew more furiously than ever (force 12), nor did it slacken before about 7 a.m., when the wind changed to SE (force 8), afterwards at noon to turn to S (force 3).

One might at first sight surmise that the Typhoon had been split on approaching Formosa, that a fragment had glided along the eastern slope of the central mountain chain at the same time as the principal Typhoon followed the other slope and that the fragmentary whirlwind had approached nearer to Tamsui and to the northern coast of the island. But in this case the port of Keelung would have been the

first to feel its passage, whereas nothing of the kind can be detected in the observations made at the Custom-house; the barometer there fell even rather less than at Tamsui, and the wind also seems to have been less violent. The rainfall however was greater, viz. from the 23rd to the 25th, 343^{mm} at Keelung and only 120^{mm} at Tamsui. This discrepancy is easily accounted for by observing that the moist North-easterly winds, on reaching Keelung, meet with a lower temperature than at Tamsui and also that they are bent up and consequently cooled on the slopes on the high hills behind Keelung: hence the condensation must be greater.

But what may have been the cause of the great fall of the barometer on the northern coast of Formosa?— To this question we confess that we cannot find any satisfactory answer for the present. Let us then only take note of the fact.

III. — THE TYPHOON OVER CHINA.

Let us now rapidly follow the depression across the country it has come to. Properly it is not a typhoon any more; the wind is far from having that frightful violence displayed by whirlwinds at sea; it is a depression of very moderate gyration, which would seem as though going to fill up and become obliterated. But this appearance is only momentary, just for the time to furnish a short career on dry land.

The direction of the whirlwind, on its leaving the Formosa Channel, bore straight to the Yang-tze-kiang; yet it only crossed it somewhat above Ichang, the last port on the river open to foreign trade (latit. 30° 12′ - longit. 119°. 19′).

We subjoin for that portion of the track, the observations made at Kiukiang, near the lake Pao-yang, and at Ichang.

			Kiukiang			Ichang		
			Barom.	Wind	Rain	Barom.	Wind	Rain
		h	mm		mm	mm		mm
August	24	10 a.m.	760.8	NE 4	—	757.2	SSE 2	—
		4 p.m.	58.8	NE 6	—	55.6	NW 2	—
		10	58.4	—	—	56.1	—	—
	25	10 a.m.	756.4	NE 7	—	756.3	NE 4	—
		4 p.m.	53.1	NE 7	—	53.6	NE 3	—
		10	54.5	—	1.0	53.8	—	—
	26	10 a.m.	755.7	SE 2	—	753.0	NW 1	—
		4 p.m.	56.0	SE 1	—	52.9	Calm	—
		10	57.5	—	1.0	52.8	—	4.8
	27	10 a.m.	757.4	SE 3	—	752.9	SSE 2	—
		4 p.m.	56.3	S 1	3.8	51.8	Calm	—
		10	57.5	—	—	52.1	—	14.2
	28	10 a.m.	758.0	SSW 3	—	753.5	SSE 3	—
		4 p.m.	56.5	SW 1	—	53.9	ESE 3	—
		10	58.5	—	0.2	55.8	—	8.1
	29	10 a.m.	759.6	W 1	—	756.5	SSE 2	—

It is easy to verify by these observations the laying out of the track about these two stations. We leave the reader to do it himself and continue to follow the depression.

On the 27th in the evening, barometric minimum (758.0^{mm}) at Chang-kia-chwang SE. Chihli; rain all day long. — On the 28th 7 a.m., barometric minimum (751.3^{mm}) on board the lightship "Taku"

at the mouth of the river of Tientsin in the Gulf of Pechihli; wind NE by E (force 4), afterwards turning to N and NW.

On the day before, at 1 a.m., there had been a maximum of the barometer at the bottom of the Gulf, but that maximum like that of Ichang, was not high and did not possess the characteristics of an anticyclone. It is not impossible that these light pressures may have been the cause of the direction followed by the storm and even of the two segmentations which took place, the first on the 26th to the west of Ichang at the recurving of the track, the second on the 28th in the Gulf of Pechihli. The reality of the segmentation is ascertained by the fact that at the two stations the barometer rose but very little after the passage of the main depression, and that the wind turned back at once to ESE and to SSE at Ichang, to the SW at Taku.

Before following the main depression over Korea and Manchuria let us see what had occurred by this time along the coast of China. — At Zi-ka-wei (latit. 31° 12′ - longit. 121° 25′) on the 26th the wind blew from SE, on the 27th from SSE; the pressure decreased gradually and very slowly; on the 28th about noon, wind from SW returning to S and SSE in the evening; on the 29th the wind returned to SW, then, at 1 p.m. to WSW *at the same time as the barometer reached its minimum* 751,3^{mm}, a thunderstorm passed in the North of the station, going from West to East with the wind. At 8 p.m. frequent lightning in the S and SE; wind blowing from NNW. On the 30th it veered to NE and settled E for the two following days. All these variations since the 28th were due to a small whirlwind escaped out of the main depression before its entrance into the Gulf of Pechihli. It descended along the coast down to about latit. 27°, where it turned to the West; it then rose towards Shanghai again, crossed the Yang-tze-kiang near Chinkiang and made away to the Yellow Sea. I should not have mentioned it but for the reason that, in spite of its insignificance as a depression, it probably greatly contributed twice, on August 29th and September 2nd, to draw back the main depression, and so would seem to have been indirectly the cause of the Typhoon of September 5th.

IV. — THE TYPHOON MAKES FOR THE EAST, SOUTH AND NORTH AGAIN.

The *Tridaly weathermaps* of the Tokio Observatory gave notice on August 28th 6 a.m., that a depression, located the day before in the North of the Archipelago, had just passed in the North-east making away for the Pacific. This it was no doubt which drew our Chinese depression to the East, towards the Japan Sea. — At Fusan, in the Strait of Korea, on its passage, Aug. 28th and 29th, wind from SW strong. At Wladivostock the barometer fell pretty low : on the 28th, one of the only two observations telegraphed to Zi-ka-wei viz. that of 9h p.m., gave 750^{mm}.6, minimum of the month with wind from SE strong. On the 29th and 30th, barometer still low, wind WSW.

Here again the *Weathermaps* of Japan enable us easily to follow the depression. After going to strike against the island of Yesso, it returned on the 30th to the Japan Sea and, on the 31st, traversed Japan over the inner sea thence to make for the South. Curiously enough the two tracks across Japan laid out on our map have all through the same inflections in corresponding places : they might almost pass for the track of a railway.

The depression makes away to the South and, in the same manner as on its first excursion to those

same quarters ten days before, it is going gradually to recruit on the sea the strength it had lost by its overland passage.

On the other hand the observations of 10 a.m. at Manila show the depression as nearing the Philippines and turning back after descending as low as the first time.

MANILA. — 10 a. m.

		Barom.	Wind		Rain
		mm			mm
August	27	761.0	SW	2	—
	28	60.7	W	1	6.9
	29	60.5	W	1	—
	30	59.9	NNW	1	—
	31	59.2	NW	2	24.9
September	1	57.7	NW	1	—
	2	57.4	WSW	5	2.3
	3	56.9	SW	5	4.8
	4	58.4	SW	2	0.8
	5	59.7	Var	2	10.2

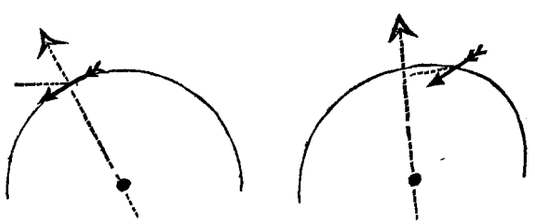
From September 3rd, the Typhoon (it now deserves that name as we shall see presently), ascends straight northward, the wind blowing from NE, then veering to N along the coast of China, and from E and NE in Japan.

Among the ships that experienced the fury of the Typhoon there are some whose reports have come to our hands, and these concur to furnish us a certain point of the track, viz. on the evening of the 5th, by 33° latit, and 127° longit; 210 miles west of Nagasaki.

1°. The British man-of-war *Cleopatra* had just left Nagasaki steering to Yokohama. On September 4th at daylight, being then in latitude 30°.38' N., longitude 129°.21' E., off the Koshiki Islands, a short deep swell was observed to be running from the South, and the sky became clouded over. The wind remained steady and moderate until 8 a.m., and the barometer was steady at 756^{mm}.9 till 10 a.m. From 8 a.m. to noon the wind and swell increased and several sails and ropes were carried away. At noon the 4th it was blowing a strong breeze from E. by N., force 4 to 6.

After noon sky became completely overcast and continued so till 8 a.m. the 6th. During the afternoon of the 4th the wind and sea increased, the swell coming from S. to SE, the barometer falling steadily from 754^{mm}.9 to 752^{mm}.1 at 7 p.m., when it blew a moderate gale, force 7. The fore and main topsails had split; at 7 p.m. the wind shifted to ENE. and the ship was still kept on the port tack. From 7 to 9 p.m. the barometer readings were unchanged; but the wind and sea increased. The ship's course was then directed to the Westward both to gain an offing from the Morrison Rocks (Kusaki Islands) as well as for the purpose of moving the ship out of the path of the storm's centre (1) as it then appeared

(1) We have here a striking instance of the inconveniences that may result from a too strict application of the law of the *eight points to the right-hand side*. Were the winds absolutely circular, chiefly when the barometer is still high, the manoevring of the *Cleopatra* was a perfectly secure one: with steady ENE. winds (as it is said in the report) a course towards the West was the safe one. But if the winds are convergent, as it is ascertained they are, especially near the coasts of Japan, to sail westwards was to go surely towards the Typhoon, as it appeared quickly on the *Cleopatra*. Here is a diagram plainly showing the fact.



to be approaching the ship, the wind having remained a long time from one direction. However, directly the ship made way to the Westward the barometer fell, and as it now appeared that we were on the right of the storm's path and approaching the centre, it was at 12.30 determined to heave to on the starboard tack, the wind having at that time shifted from ENE. to EbyN. again; at midnight the barometer stood at 749^{mm}.3 and at 11 p.m. a very sudden and heavy squall (force 9) struck the ship. This squall blew with such violence and came with such suddenness that had we not been running before the wind it is doubtful if our sails could have stood its strength.

They were not able to stand it a long time; for after 8 a.m. the wind shifted to ENE. and at noon blew from EbyN. a storm (force 11). The ship being under storm trysails, the fore staysail stay having been carried away at about 5 a.m. and the fore staysail having been taken in and all the square sails except the spare mainsail having been now split or torn. 6 a.m. or daylight the 5th showed a heavy confused short sea was running from the eastward, which became worse at noon. The ship behaved very well, but lurched heavily to leeward taking water in over the lee nettings. The wind remained at EbyN. until 5 p.m., barometer 728^{mm}.7 when a heavy squall struck the ship and the wind shifted to E ½ S. and was accompanied with very heavy rain, and the spoondrift was flying thicker than usual. This was followed at 6 p.m. by a comparative lull. At 7 p.m. another very heavy squall with a shift of the wind to SEbyE. followed, and continued till 8 p.m., barometer 728^{mm}.7.

At 9 p.m. the barometer stood at 726^{mm}.2 the lowest registered, and in the interval during a slight lull the head of the fore trysail was hauled in to enable the ship to lay a little closer to the sea. After 9 p.m. the clouds although completely covering the sky appeared to rise, and caused an appearance of more light. The lull continued till about 11 p.m.

From midnight of the 6th to 4. a.m., it continued to blow extremely hard, the barometer rising from 729^{mm}.5 to 738^{mm}.9; the wind during this time shifted from SE. to SWbyS. At 6. a.m. the whaler was washed away by a heavy sea : barom. 740^{mm}.9.. At noon position : lat. 31°.53′. — longit. 128°.45′; at noon of the 5th no observations were obtainable. From which we may see that the *Cleopatra* had been carried by the storm as far as very near the track, and almost to the centre itself.

2°. The German sailing ship *Auguste,* sailed from Ningpo for Nagasaki on August 31st; had to cut down her masts to keep afloat in a terrific sea under the assaults of furious squalls from NE. On the 4th, 6 p.m. the barometer fell to its lowest point 731^{mm}.5. The wind was then NNW, and kept from that quarter till the next day about noon, when it turned to WSW. It is probable that the ship was carried towards the centre, for the report mentions a moment of calm at 3 a.m. on the 5th, the barometer not rising again before 5 a.m. No information however as to the position of this ship.

3°. The Japanese steamer *Yoritomo Maru* left Kuchinotzu on the 4th, after noon. On the 5th noon she was in 32°. 0 latit., 127°. 10′ longit.; wind blowing furiously from NE.; hove to at 9 a.m.; not before the 6th 4 a.m. did the wind turn to N and soon after to NNW; at 5 a.m. settled to SW; barometer, which had been standing at 746^{mm} (?) since the preceding day 6h p.m., began to rise. Considerable damage on board.

4°. The last ship is the steamer *De Bay*. Left Nagasaki for Shanghai on the 4th after noon. On the 5th after midn. wind ENE freshening rapidly; at 6 a.m. already blew a storm; minimum of the barometer observed at 10 p.m. Two hours later the wind passed to NW through N; on the 6th 4 a.m.

blew from W and SW yet stronger if possible. Hove the ship to for thirty six hours: position, latit. 32°.30′, longit. 126° 30′. Here also considerable damage was done.

Did the Typhoon enter the Japan Sea through the strait of Korea? — The observations made in the very Strait, at Fusan on the Korean coast, show that it did not. The barometric minimum, 746.9^{mm} was observed on the 6th, 6 a.m.; the wind was still blowing from NE (force 10), but it soon after turned to ESE through E (force 7), at noon to SE (force 5), at 6 p.m. to SSW (force 5) and to SW (force 7) where it settled for the next two days, abating pretty rapidly.

The rotation through the South shows that the Typhoon remained to the West and continued its course northward. For, failing the bulletins of cape Shantung for September which have not come to hand yet, we can consult those of the light-ship *Taku* at the mouth of the river of Tientsin and those of the light-ship *Newchwang* at the mouth of the river leading to the port of that name at the bottom of the Gulf of Leaotung (latit. 41°). For the first the barometer had its minimum 750.0^{mm}, on the 7th, 7 a.m., wind NW (force 4-5); for the second the minimum, 745.5^{mm}, occurred about 3h p.m.; wind N (force 5), turning during the following night to WNW and W; thence it follows that the centre of the Typhoon came to pass within a short distance east of Newchwang, in the afternoon of the 7th.

Lastly the observations of Wladivostock, like those of Fusan and those of the eastern coast of Japan, prove that the Typhoon did not approach that port across the Japan Sea, but over the interior of Manchuria. It is what results from the following observations telegraphed daily to Zi-ka-wei.

WLADIVOSTOCK

[Lat. 43°.7′ Long. E 131°.54′].

	Date	Hours	Barom. mm	Wind.		Rain mm
September	5.	9. p.m.	762.0	SE	2	—
,,	6.	7. a.m.	60.6	S	1	—
		9. p.m.	57.7	SE	1	—
,,	7.	7. a.m.	57.2	N	1	—
		9. p.m.	55.7	SE	4	—
,,	8.	7. a.m.	54.9	SE	6	35
		9. p.m.	54.1	SE	7	—
,,	9.	7. a.m.	55.7	SW	7	14
		9. p.m.	59.8	SE	4	—

We here part with the whirlwind, having followed it from August 17th and come back with it almost to our starting point.

CONCLUSION

It was hardly possible to find a better example to prove what I had in view. Either the typhoons of the China Sea are not like the storms of the other parts of the world, or new principles must needs be admitted with regard to the motions of those great atmospheric whirlwinds and the actions they exert upon one another. To any one who had only seen the track of this double Typhoon, which track besides might easily had been protracted at both ends, atmospheric whirlwinds, either at sea or on land, would seem to follow all imaginable routes, guided as it were by the attraction of the moment. But to complete this too rapid inquiry, it would have been necessary to indicate, summarily at least, the various actions exerted on the Typhoon by other storms moving in those vast regions at the same time some of which had their origin in segmentations of the Typhoon. The China Sea, western China, Mongolia and Manchuria

and lastly the region of the Pacific to the north-east of Japan were in turn the scene of such evolutions, and according as one or the other of those whirlwinds acquired more importance, either from greater proximity or from any other cause, we might have seen our typhoon bearing towards it. We should also have seen attractions succeeded by real repulsions, thanks to which each whirlwind preserves its individuality and prolongs its existence.

The object of this short paper is not however to call attention to this particular point; I only want to contrast the excursive wandering of our Chinese Typhoons with the regular *parabolic* (!) tracks too often ascribed to their congeners in other regions.

When an atmospheric depression disappears altogether from our quarters, it is to become lost in the North Pacific and therefore in this case its progress is really from West to East. But, in the general case, how many difficulties will it not have to overcome before finding that wide open road! It has, as it were, to fight its way step by step, undergoing repeated segmentations and giving birth to whirlwinds even more important than itself, so that it is lost sight of and abandoned for its offspring.

Such is the view I am led to take of these atmospheric phenomena in China, and I cannot but think that they must be similar everywhere though with differences necessarily arising from another relative distribution of land and water: an atmospheric whirlwind, for instance, which should reach the continent of Europe, with the Atlantic behind it, must needs behave differently from a whirlwind issuing from the continent of Asia and having before it the immense waste of the Pacific.

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SECOND PART

The foregoing paper on the two Typhoons of the end of August and beginning of September 1885, had been drawn up first at the request of a few Captains. I now turn back in order shortly to review the most important facts which marked the Typhoons of July and August, the first its seams of the summer of 1885.

The various tracks of the Typhoons show that every one of them, and particularly the two (3rd map: July 13th August 7th) which immediately preceded those above described, might quite as well have been taken for proving that the origin of the Typhoons which approach the Philippines must be looked for rather in Japan than in the regions situated to the South-east of the Spanish archipelago. I shall content myself here with bringing forward again an argument already adduced by me elsewhere in support of this view. Is it not a curious fact namely that, whenever a Typhoon is signalised to the east of Luzon, there should have been, a few days before, a depression setting out from Japan and making for the South?—and mark that, as far as ascertained, the two partial tracks always can quite naturally be tacked on each other. Is not that fact alone a strong argument in favour of my opinion?

Those depressions however are nothing less than Typhoons when they cross the Japanese archipelago. In the common case, there has been a splitting of a storm; one of the fragments remains in the Sea of Japan or makes away towards Yesso and Saghalien, while the other descends to lower latitudes. At the moment of the division which in most cases takes place within the boundaries of Japan, it is natural that the depression should be but irregularly shaped out and the winds light; but a glance at the maps of the Tokio Observatory can leave no doubt as to the fact and the direction afterwards taken by each of the whirwinds. Lastly it happens that about two days after the segmentation, a close observation of the atmospheric phenomena on the southern coast of Japan gives to surmise the existence in the South of a depression which grows more and more important as it becomes more isolated from land on the vast extent of sea which separates Japan from Luzon. Land is fatal to Typhoons (July 2nd on the north of Japan; - July 19th, north of the Formosa channel; - August 3rd, east of Shanghai; - August 25th east of the Formosa channel); the sea, on the contrary gives them energy and restores what they have lost on land. Thus it is that we see almost insignificant depresions issuing out of Japan and lower down being transformed into Typhoons, or passing from the continent of China into the Yellow Sea, on their way to the Pacific over Japan.

FIRST TYPHOON : CROSSES JAPAN ON JULY 1st AND 2nd.

This Typhoon is remarkable for the short space of time that sufficed for its development so as to entitle it to that appellation. On June 24th it was but a light storm come from the interior of China, and running pretty rapidly towards the North-east. On the next day, 25th, after noon, the Str. *Chungking*, Capt. Th. Shaw, bound for Chefoo, met with it near the Shantung promontory; barom. 745^{mm}.3; the wind, then WNW (force 4), had been turning from E through SE and S to SW and W.; on the 26th it came to N near Cape Shantung. All that time, diluvial rain; high confused sea from SE and from W.

From thence the depression passed into the Sea of Japan and issued from it on the 27th and 28th through the Strait of Tsugari. There it was at once attracted to S and SW by another Chinese storm which, on the 28th, reached the sea along the Yang-tze-kiang and next day, the 29th, under the attraction of the Japanese depression, shot through the Strait of Korea into the Sea of Japan. The Typhoon once below Japan, there was no cause why it should continue to run towards China, the storm towards which it was impelled being already in the north of the Japan Sea it was to that quarter that it must proceed.

Some ships that, on the 29th. left the bay of Yedo, remove all doubt about this fact. No sooner had they sailed out to sea that they experienced thick weather, with rain and strong NE squalls. This is especially the case of the British barque *Androklos*, Capt. Watt; the report tells that this weather continued up to 4 a.m. on July 1st, when the wind hauled round to the westward, shifting immediately afterwards to SE and rapidly increasing. At 8 a.m. the barometer stood at 751^{mm}.8, falling fast — 4.30 p.m. 723^{mm}.9, lowest reading. During the whole of the day the wind and sea increased until both were terrible. — 4.30 p.m. cut away the foremast to save the vessel from foundering. — Wind veered round to SW. and moderated towards dusk.

The German barque *Francisca*, Capt. Garm, left Yokohama on 30th June, in ballast, for Newchwang; towards evening weather became thick and misty with rain, wind very variable, changing from N. to E. and SE. During the night wind increased, and on the morning of 1st July it was blowing a gale, with a very high sea. Barometer falling. At noon, latit. 33°.39'—longit. 137°.54', wind veered round from SE. to S., and barometer continued falling, with heavy rain and all signs of an approaching typhoon — 2 p.m. barom. 745^{mm}.2, wind and sea getting heavier every minute — 2.45 p.m. the typhoon seemed to be at its highest, barometer 741^{mm}. To save the vessel and lives cut away main and fore topmasts and the main-mast too as the ship would not rise. etc.....

While the Typhoon recurved, on June 30th strong NW winds blew on the coast of China above Formosa, with confused sea.

On July 1st noon, the centre lay close to the southern coast of Nippon: only an hour before the French Str. *Tanaïs* had experienced all its fury; — barom. 730^{mm}., wind NE blowing a storm; turned to N and NW.

All along Japan the whirlwind preserved the same force and the same size but it gradually lengthened, a sign of an impending segmentation: this took place in the night of the 2nd to the 3rd; one of the fragments, probably the larger, made away into the Sea of Okotsk, while the other passed over Siberia and Manchuria. At Wladivostock the minimum of the barometer did not occur before the night of the 3rd to the 4th; wind, SE (force 4).

2nd TYPHOON: JAPAN AND FORMOSA.

On July 3rd there was a depression making awag from China, somewhere above Shanghai, in the direction of Japan. It was met on the evening of the same day, about latit. 33°, by the Str. *El Dorado* Capt. Jackson, coming from Chefoo: wind SE (force 7), barometric minimum, 746^{mm}.0. The wind turned through W. — The passage of the two depressions of June 24th and of July 3rd brought seasonable rains to the North of China then suffering from drought and just saved the crops.

In Japan there was nothing worth noticing, in spite of the two successive visits of our depression on the 5th and on the 9th. The division which it underwent there checked its development and it was only on the last passage from Japan toward Luzon, and afterwards toward Formosa that it had all facility to recruit its energy.

I will only note that the British steamer *Amatista* which left Tamsui (North Formosa) on the 7th July for Amoy, reports strong SW. gale with heavy rain throughout, a sure indication of an important depression northeastward off Japan on the 7th and 8th.

At Manila the barometer only sank to 756^{mm} on the 16th, at the moment of the greatest proximity of the centre; the wind was blowing from SW since the evening of the 14th; on the 16th it passed to WSW (force 5) and on the next day, 10 a.m., to SSW (force 3).

The Typhoon was called toward China by a strong storm which on the 16th passed to the north of Peking, and by another which on 17th lay over the Yang-tze-kiang. On the 16th the Str. *Chungking* was sailing up toward Chefoo with a strong wind from SSW; on the evening, when she arrived at Taku, at the bottom of the Gulf of Pechihli, the barometer showed a minimum of 746^{mm}.

On the 17th between 3 and 6 p.m., barometric minimum at South Cap light-house (Formosa); wind WNW (force 6).

On the 18th, the centre of the Typhoon skirted the northern coast of Formosa. At Tamsui, on the 16th, after several days of fine weather, the barometer had commenced sinking, and the sky was getting overcast. On the 17th, 9 p.m., the wind blew strong from NW (force 7-8); on the morning of the 18th, it turned to W, and in the afternoon to SW, with strong squalls (force 9-10) accompanied by torrents of rain. On the 19th, about 3 a.m., the wind veered to S, then to SE and abated gradually. It was on the 18th, 4 p.m. that the barometric minimum, 744^{mm}.0 was observed at Tamsui.

The French Mail-Str. *Peiho,* Capt. Guiraud, was at the northern entrance of the Formosa channel at the moment of the passage of the centre. The barometer reached its lowest point, 745^{mm}.5 on the 19th 5 a.m., that is an hour later than at Tamsui. The wind, exceedingly strong since 8 p.m. on the preceding day, turned from E to SE (barom. minimum), then to S and SSW.

The Typhoon of July 1st, as mentioned above, had run up all the length of Japan over the mountainous land without any loss of strength; the present Typhoon of the Formosa channel, on the contrary, could not meet the coast of China without collapsing: it died out as it were, on the spot. The reality of this curious fact is gathered from several indications. And first, at Middle dog light-house (latit. 26°.0 - longit. 120°.0') the barometric minimum took place on the 18th between 3 and 6 p.m., though the station was almost upon the track of the Typhoon. This light-house is 85 miles to the North-West of Tamsui where the barometer, as stated above, had its minimum on the 19th, 4 a.m. At the light-house

the barometer remained afterwards almost stationary to about 10 a.m. on the 19th. As for the wind since the 17th it had been oscillating between NNE and NNW (force 5-6). On the 19th midn. it came to WNW (force 5); then at 9 a.m. turned pretty rapidly to SW (force 5), at noon to S (force 6 increasing to force 7-8 at 3 p.m., this being the worst of the storm), and lastly to SSE (force 4) in the evening. Thus even on the coast of China the Typhoon had lost both its regular shape and its violence. — But we find a still more striking proof of this fact in the winds that blew at Foochow, situated to the east of Middle dog and somewhat distant from the coast. There, according to the meteorological bulletin of the customs, on the 18th 9 a.m. the wind was NW (force 1); at 3 p.m.; NE (force 1); on the 19th, 9 a.m. and 3 p.m., NW (force 1); on the 20th it came to SE and to S, abating still more. Thus already about thirty miles from the coast, there was no more Typhoon and, were it not for the variation of the barometer which was not insignificant, there would have been at Foochow nothing to indicate the passage of an atmospheric depression within such a close proximity. — Lastly, if we seek for some traces of its passage on central China, we do not find any, even at Kiukiang, the port on the Yang-tze-kiang nearest to the track if the Typhoon had continued to proceed. There was, it is true, a storm felt along the river, but it was on the 17th, not on the 19th, and it is to its attraction that the direction last followed by our Typhoon may be ascribed. — I am mistaken: on the 19th, 1 p.m. an enormous waterspout crossed the Yang-tze-kiang, running from NW to SE, at Wuhu, which port is southward of Nanking, westward of Shanghai. The Typhoon had already vanished near the ground, when in the middle regions of the atmosphere there were still important partial whirlwinds.

In the South, at Hongkong and at Pakhoi the barometer was rising since the 17th; it was not then towards that quarter either that the Typhoon could have gone: therefore it must necessarily have vanished, and the Typhoon which, at that moment, was rapidly approaching Luzon and Formosa from the open Sea, is not unlikely to have had a share in that termination.

THIRD AND FOURTH TYPHOONS: — JULY 17th — AUGUST 7th.

On July 15th a storm was approaching Wladivostock over Siberia and driving away across Japan a centre of depression which occupied the north of the Japan Sea. This centre it is which, a few days later, gave birth to our two new Typhoons. The Siberian storm, having been attracted in its rear, traversed Japan in its turn on the 17th. The weathermaps of the Tokio observatory show it afterwards lingering near the eastern coast and spreading over the Archipelago as far as the Japan Sea. It would seem that it was detained in that quarter by our depression which, on the 18th and 19th moved rapidly southward, becoming greatly developed during that long passage over the open Sea. Its course was further accelerated by what was then happening to the north of Formosa, where the preceding Typhoon had just died out suddenly, only leaving in its place a simple depression well fitted to draw to those quarters the Typhoon come down from Japan.

On the evening of the 18th, the barometer reached its maximum 759^{mm}.2 at Manila; wind from N, very light. Two minima both of 752^{mm}.6 were registered on the 21st and 22nd 4 p.m. Wind WSW (force 5) on the 21st; on the 22nd 10 a.m. its force had increased to its maximum, 8. It settled between W and SW, abating till the 25th, afternoon; it then took the force 4, while the barometer kept almost

stationary to the end of the month. There is nothing in the Manila observations to raise even a suspicion that the two Typhoons which passed in the vicinity of Luzon on July 22nd and 30th might have come from the south-east of that Island: the winds blowing constantly from W or SW point to the North-east as their birth-place, and it was in that direction that they were from the first to be sought for.

The first, on the 22nd and 23rd, penetrated along the northern coast of Luzon into the north of the China Sea, but it was not to go far in that direction: it was called back to the east of Formosa by a depression which had separated from it, very likely on its coming against the high mountains of that great Island, and which now was flying away eastward.

The observations made at the South-Cape light-house furnish us with a good example of the curious effect of the splitting of a whirlwind upon the air interposed between the two centres. This splitting seems to have taken place on the 22nd about noon; for, at the Cape, the wind, which at 10 a.m. was NE (force 4) abated considerably about noon and turned to N. The barometer sank till 9 p.m., and then kept stationary to the 23rd noon. This effect was due as much to the eastern whir wind making away rapidly as to the fact that the nearer whirlwind kept at a distance from the light-house and described a curve in the West. At 9 a.m. the wind came to NW (force 1); at noon it even turned to WNW (force 1) evidently under the influence of the Typhoon in the offing, which at that moment was already far more important than the other.

At 3 p.m. the wind returned to NE, equally light, and kept so to 9 p.m. The current of air was actually running towards the nearer Typhoon, but the wind could not freshen yet by reason of the draught still exerted from the East. On the 24th, midn. the wind was SE (force 2): the whirlwind was beginning to form again near the western coast of the Island. At 3 a.m. the wind freshened more; at 6 a.m. barometric minimum; the wind had just (5h. 40m. a.m.) turned suddenly to NW (force 6): the real storm was beginning. It was that the Typhoon had just crossed the South point of Formosa in pursuit of its fellow: wind, at noon NW (force 8); at 3 p.m. force 9; it then gradually abated, turning to WNW.

It might perhaps be supposed that the depression just issued out of Formosa had come from the interior of the China Sea. But, before fixing upon a splitting of the Typhoon descended from Japan and signalled to the east of Luzon by the observations made at Manila, I had searched in the observations on the coast of China and as far as the bottom of the Gulf of Tonquin for some traces of the presence of a depression in that sea before the 23rd, but found nothing at all to support such a conjecture. Besides, after the splitting, the depression that came to the West was so weakened that the winds were constantly light along the southern coast of China, even on the 23rd, when the centre was nearest to it. At the Pescadores, far less distant from Formosa and of the track followed by the depression, the wind kept NNW (force 3-4) on the 22nd, and N (force 5-6) on the 23rd. On the 24th it blew W and SW (force 3-2): the high mountains of the Island intercepted the aerial currents.

While the Typhoon dropped near Luzon goes off careering far away to the East, let us follow that which has just left Formosa. The pursuit it seemed to have set out upon, and which might perhaps have been continued if it had not so soon become developed to the east of the Island, had to be given up on account of the relative proximity of the other whirlwind; it had then to turn northward to fly from its antagonist.

The British steamer *Cicero*, Capt. A. George, left Kuchinotzu, Japan, on the 22nd July with a

cargo of coals for Hongkong. On the 24th and 25th, when in latit. 29°.16' - longit. 125°.14', she encountered a severe typhoon, wind commencing at SE. veering round by E. and N. and finishing at NW. The ship was hove to on the port tack for 39 hours, from 1 p.m. on the 24th to 4 a.m. on the 26th, during which time she was constantly swept by the sea fore and aft. The port gig was smashed, the cabin flooded, pipes and ladders about the decks were smashed and sundry other damage done. The barometer fell from 762^{mm} at noon on the 24th to 735^{mm}.6 at midnight. It commenced to rise only at 6, a.m. on the 25th, wind NW. again increasing; — at 7 a.m. NW. blowing with hurricane force....

The British Str. *Kashgar*, Capt. Speck, from Nagasaki to Hongkong, crossed the track on the 25th 7 a.m., about latit. 30°, longit. 126°.—barom. 724^{mm}., heavy sea, furious wind, much damage on board.

The British sailing ship *Omega* was overtaken by the storm about the same point as the *Kashgar*.

At Nagasaki, 2 p.m. the barometer stood at 747^{mm}. with the wind S (force 6); at Zi-ka-wei on the opposite coast, the barometer at the same time marked 752^{mm}.3, wind NW.

The Typhoon was acted upon by Korea in the same way as by Formosa : it was divided into two depressions, one of which went into the Japan Sea, while the other rose up the Yellow Sea. This was the end of the Typhoon.

Let us now return to the South where we left part of our primitive depression. That it had split in two and that one of the fragments had at once have made away eastward, seems well established. It is not quite so certain that it was identical with the Typhoon which, from the 26th to the 31st, assailed first the sailing ship *Nicoya*, Capt. J. Foster, then the sailing ship *Wallace*, Capt. Smith; and yet, in support of that opinion, which we have followed in laying out the map, there are strong reasons, of which we will give two.

On July 26th noon the *Nicoya*, sailing from Sydney to Shanghai, lay in latit. 21°.9', longit. 136°.12'. The Captain report begins at this date. «Very wild appearance of the sky with lurid lightning to eastward; wind N squally with rain resembling sleet, being so much colder than the air. A Typhoon appears to be approaching from the eastward; kept ship off to SW.» Barometer still high, but falling. Every thing then seemed to betoken a Typhoon approaching from the East. Where could that Typhoon be coming from in the open sea?

We have seen above that, on the 24th and the 25th, the Formosa whirlwind made away northward towards Korea, acquiring at the same time an extraordinary strength. Its antagonist which had first fled from it to eastward, must soon be called back, if our theory of the attractions and repulsions of whirlwinds is true. As the dispersion and premature end of the first left the field clear, it also must have drawn nearer to the continent, where the pressure at this time is always low. Besides we know that, for all the time of that long excursion from the 22nd to the 30th between Japan and the Philippines, the wind at Manila kept steady from WSW; the barometer had a maximum on the 20th and a minimum on the 30th, the total fall not exceeding 4^{mm}.6. On the other hand the *Daily Weathermaps* of Japan show no traces of any storm having left at that time the eastern coast and consistent with the observations made on the 26th and 31st by the sailing ships. Lastly, since this Typhoon came from the very quarter to which we know a whirlwind from a recent segmentation to have gone, which whirlwind according to all probabilities, must soon have retraced its steps to draw nearer to the whirlwind left behind, we have no alternative but to identify this whirlwind detached on the 22nd with the Typhoon of the 27th—31st, the

point of retrogression being somewhere about latit. 35°, longit. 140° at the date of the 26th.

Let us now return to the report of Capt. Foster.

On the 26th every thing betokened a Typhoon in the East running straight to westward. To keep its route would have been highly dangerous; wherefore steered to SW. and shortened sails.

On the 27th, at daylight, NW. gale with every appearance of bad weather; lower scud flying from NW, dense black clouds flying from SE. At noon latit. 20°, longit. 135°.37'. Barometer still at 754mm.4, having sunk only 6mm in the 24 hours, thanks to the alteration of course on the day before.—P. M. weather getting much worse, wind veering to W. with furious gusts and torrents of rain.

On the 28th, 10 a.m. hove to on port tack (to let the centre pass to the North). Very heavy confused sea, heaviest from NW.—Noon; hard gale with fierce squalls, veering to SW. Barometer stopped falling; minimum: 749mm.3 (the centre had been avoided).-4 p.m. set fore topsail and kept ship off to NE.

On the 29th, noon. Latit. 21°.5'-longit. 136°. SE. gale with very heavy sea; barometer risen only by 2mm.5. Steered NW. 4 p.m. wind and sea increasing, barom. falling; steered N, as the ship appeared to be approaching the storm again.

On the 30th and 31st, strong steady SE wind. On the 31st 11 a.m., in sight of Borodino islands (latit. 26°-longit. 131°.20'). Wind and sea getting worse; barom. falling again (because the ship, impelled on by the strong SE wind and making for the coast of China, was getting nearer again to the centre).

August 1st. noon, latit. 26°. 40'-longit. 129°. 55'. Barometer keeps falling, storm from SE more and more furious. Trusting in the qualities of his ship, Capt. Foster seems to have purposely run close to the Typhoon whose direction was precisely that he was following himself. In fact the SE and ESE winds, in which he managed to keep, carried him to the Yang-tze-kiang, where he anchored on August 4th 6 p.m., 24 hours after the passage of the centre of the Typhoon.

This most interesting report, which enabled us to follow our Typhoon step by step on a stretch of twenty degrees of longitude, is borne out by that of another ship less fortunate in her struggle against the raging storm. We mean the *Wallace* which suffered such damage that, after tossing about under a jury mast to August 16th, she had to be towed into Shanghai where at this date (November 16th) she is yet in dock under repair.

This British ship, 1583 tons, Capt. W. H. Smith, had left Nagasaki on July 27th 6 a.m. bound for Hongkong with a cargo of coal. The weather was fine at the time, with the wind SE, which continued till noon of the 30th, when the vessel was 30 miles SW of the Loochoo Islands. The barometer had been falling gradually for the previous twenty-four hours, but in the afternoon it commenced to go down rapidly, with every appearance of a Typhoon. Why then continue on the same route? — It was blowing a heavy gale from ENE and the ship was hove to on the port tack. — This seems to have been another error. Would it not have been better to move away from the track of the typhoon, and maybe lose a few hours in running over a curve in the directions of NW, N and NE, than to wait the arrival of the centre which, according to all probabilities must pass close to the ship? For the gale continued to increase in fury during the night, and by midnight of the 31st the glass had fallen to 724mm.

The wind, says Capt. Smith, was blowing with a force impossible to describe, burying the lee

(starboard) side of the ship under the water, shifting the cargo, and driving the vessel in a direct course for Providence Reef at the rate of about 4 miles an hour. By 4 a.m. on the 31st, the ship was apparently fast settling down in the water, as the water coming from the pumps was black, showing that it was among the coals. Some one was sent down the pump well hatch, and he found that the vessel was more than half full of water. Although the two pumps were kept continually going, it was fast increasing, and the vessel heeled over on her side so that the upper dead eyes on the lee side were under water. Capt. Smith managed to get along to the main hatch and found it was under water, the tarpaulins having been washed away and the hatches stove in, while the water was going down in great volume. A large sail was then dropped over the open hatchway, and when it was sucked down on the top of the opening, it was secured by ropes and planks. By this time the *Wallace* had drifted to within 7 or 8 miles of Providence Reef, the wind having continued steady ENE up till now; but it fortunately suddenly shifted to ESE, Providence Reef being about W. It was thought that if the ship could be got before the wind, she could be kept with it on the starboard quarter, and this would give her a NW course, enabling her to clear the Reef. Lying on her side as she was, she would not answer her helm, and it was impossible to put any canvas on her, so the mizzen mast was cut away, and it fall over the starboard side; but as the lanyards of the wire rigging on this side were under water, they could not be got at, consequently the wreckage remained alongside. When the mizzen mast fell, it carried away the main top-gallant mast and the head of the main top mast, also the fore top-gallant mast, which broke off above the top mast. These, however, did not go over the side for many hours, but were dangling about overhead in a very dangerous manner. The mizzen mast having been cut away, the ship immediately fell off before the wind, which hauled SE. The ship kept NNW, then N, and at 8 a.m. NNE. She was then well clear of the Reef to the northward, but the toller broke off and the ship at once came to the wind.... The barometer now began to rise gradually, but the wind was harder than before — a state of offairs which continued all day. There was 14 feet of water in the hold, notwithstanding that both pumps were going, the crew having been working at them for twelve hours. Throughout all the day the wreckage was continually thumping the counter and threatening to stave in the planks, besides tearing off the copper. All this time the wreckage on the main and fore masts was working down, breaking and carrying away the lower iron yards, and eventually all fell into the water and got under the ship's bottom.... The gale continued with little abatement until the morning of August 3rd, when it moderated. Up to this date the *Wallace* had drifted fully 300 miles in the track of the storm. — On the return of fine weather, after ineffectual attempts at sailing, the ill-fated ship ultimately reached Shanghai in tow of the tug *Fuhlee* sent to her assistance.

The foregoing long extract of the report (*N.C. Daily News*) on this casualty has been given to show how dangerous it is to face the storm when lying on its track. The comparative slowness of this Typhoon and its well marked direction from East to West afforded, we think, all facility and gave ample time to get out of its course. Perhaps was the direction of the storm mistaken : hence the wrong manoeuvre. Let professional men appreciate the case and profit by it.

We have seen above how the Typhoon of July 18th came to collapse against the Chinese coast, north of the Formosa channel. The same fate awaited the Typhoon of the *Nicoya* and of the *Wallace*, with this slight difference that its existence can be traced down to August 7th, but from the 4th it had lost all violence. Land had been death to the Typhoon, though there remained an atmospheric

depression weakened and of no importance.

The Typhoon made the coast of China at Ketan Point, east of Ningpo and south of the Island of Chusan. The short distance, about 50 miles, it had to go over land to reach Ningpo, already sufficed greatly to impair its energy, which it had yet preserved at sea higher up, along the southern coast of the Gulf of Hangchow. The particulars of these changes are set off in the following documents comprising the observations made both at Ningpo and at the Steep Island light-house, situated a few miles to the north of Ketan Point.

NINGPO
latit. 29° 52′—longit. 121° 33′.

	Barom.	Wind	
	mm		
August 1 noon	754.6	NE 1	
4 p.m.	54.1	NE 1	
8	53.6	calm	
2 midn.	54.1	NW 1	
4 a.m.	52.1	NE 1	
3	52.1	NE 2	
noon	51.1	N 4	
4 p.m.	49.0	N 5	rain
8	44.5	N 8	,,
3 midn.	43.4	N 8	,,
4 a.m.	43.9	SW 8	,,
8	46.5	SW 8	
noon	48.5	SW 4	
4 p.m.	49.0	SE 2	
8	51.6	S 2	
4 midn.	52.1	S 2	

STEEP Light-house
latit. 30° 12′—longit. 122° 36′.

	Barom.	Wind	
	mm		
August 1 noon	753.1	NE 4	
6 p.m.	52.9	NE 4	
2 midn.	52.7	NE 6	
6 a.m.	50.4	NE 6	
noon	49.3	ENE 6	
3 p.m.	47.7	NE 6	little rain
6	45.2	NE 7	,,
9	41.8	E 9	,,
3 midn.	36.6	E 12	,,
1 a.m.	36.3	SE 11	rain
2	36.8	S 10	,,
3	39.4	S 10	,,
6	44.9	S 7	
noon	49.5	S 6	rain
6 p.m.	50.1	S 6	
4 midn.	53.2	S 5	

At North Saddle Light-house, 36 miles north of Steep the barometer at midn. marked 742^{mm}.3, wind E (force 10); at 3 a.m. 741^{mm}.9 wind ESE (force 10).

At Zi-ka-wei, 95 miles to the north of Ningpo, the barometer only reached its minimum, 740^{mm}.76, at 5h 30m a.m.; wind ENE, veered to SE in the morning and afterwards settled SSE. The greatest velocity registered by the anemometer of the observatory tower (41^{m} above the ground) was 97 kilom. between 3 and 4 a.m.

Thus according to these data, all the northern part of the whirlwind had preserved its original violence and the depression was maintained better than in the southern part, where the winds must have blown from West; these latter could not fail to be lighter than those whose direction was from sea landward, because of their higher temperature and of the lightness of the general pressure.

At Chinkiang, 110 miles to the north-west of Zi-ka-wei, the wind blew from NE (force 7), showing some energy yet left in the Typhoon; the barometric minimum, 746^{mm}.4, only occurred between 4 and 7 p.m. The wind turned afterwards to E (force 5), to SE (force 3) and lastly, on August 5th, to SW (force 2-3). From the moment of the barometric minimum, the winds blew almost straight to the centre which, after running up some distance to North-West while becoming weaker and weaker, turned again to East on the 5th, after dropping a fragment in the West. — Such was the end of this Typhoon, remarkable for its long wanderings, its double existence and the violence it displayed on its two tracks.

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PART III

1°. Typhoon of the 11th-19th September 1885.

In the first part of the present paper we followed a Typhoon from August 17th to September 9th, and left it almost in a dying condition just on the shore of the Japan Sea, where we had first found it. The main land, by parcelling atmospheric depressions out into several whirlwinds, soon makes an end of the fiercest storms, a fact of which we have had remarkable instances: but on the other hand we have observed over and over again that the return to sea of a whirlwind usually restores to it its primitive energy. It is precisely what happened with the depression we had left over Manchuria on September 9th: we shall now be able to follow it a little longer, down to the 20th of the same month.

On the 11th 2 p.m., it was near the strait of Tsugari which separates Nippon from Yeddo, seeking the easiest way down to the Pacific. Part of the storm continued running eastward, while the remainder bent southward, as usual with the whirlwinds that creep into this strait, a particular instance of which fact we had in the depression of June 27th.

Like this latter also, our storm of September 11th shall very soon pass into a real typhoon.

Not having descended so far South as the Typhoon of June 30th and July 1st, the Typhoon of September 12th and 13th only made its presence felt at Manila by light westerly winds, and by a moderate fall of the barometer. Yet a copy of the observations wired daily to Shanghai may be of some interest.

MANILA (Luzon).

Date	Hours	Barom.	Wind		Rain
		mm			mm
September	11 10 a.m.	761.2	SW	1	—
	4 p.m.	59.2	WSW	2	—
	12 10 a.m.	60.5	W	2	—
	4 p.m.	58.2	W	2	—
	13 10 a.m.	59.7	SW	1	—
	4 p.m.	57.7	NE	1	—
	14 10 a.m.	60.5	NW	1	—
	4 p.m.	58.5	ENE	1	—
	15 10 a.m.	60.7	W	1	—
	4 p.m.	58.4	E	2	0.08
	16 10 a.m.	60.5	WSW	1	—
	4 p.m.	57.9	SW	1	—
	17 10 a.m.	60.5	W	1	—
	4 p.m.	57.9	W	1	—
	18 10 a.m.	60.7	SW	1	—
	4 p.m.	58.7	WSW	1	8.90

It is interesting to notice the divergence of the winds when the centre passed at its shortest distance from the station. If we compare the variations of the barometer for the following days, with the path laid down on the annexed map, we shall easily understand why the glass did not rise more rapidly over Luzon after the 13th, but even showed a fall again between the 16th and the 17th.

No sooner had the depression begun its rotatory movement round Nippon, than high pressures spread over the centre of that island, while the barometer began to fall in the south of the Archipelago and over the Japan Sea on account of a strong storm coming from the West, through Manchuria: this fall it was that called towards the same quarters our Typhoon, already fully constituted and which on the 12th accelerated its course.

On that very day the American barque *Cashmere* was at noon by 29°40' lat. and 134° long. about 240 miles south of Shikoku Island; the wind, the direction of which is not mentioned in the report (probably NE or N) freshened rapidly, and the sails were gradually shortened. But very soon the fury of the storm increased to such a degree, that the ship was obliged to run under bare poles: the Typhoon reached its worst, it seems, about 5 p.m., and the luckless ship being thrown on her beam ends, the Captain gave orders to cut away the masts. About 11 p.m. the second officer was swept overboard, the chief officer sharing the same fate about half an hour later. About 3 p.m. on the 13th, the Captain and his son left the after part of the ship to go forward, where the sea appeared to be breaking with less violence. The boy succeeded, but he experienced the horror of seeing his father swept overboard. Seven men who were daring enough to venture themselves in the only boat that had not been carried away, had a narrow escape, but landed safe on the shore of Japan. Five others thought more prudent to remain on the wreck.

At Nagasaki, on the 13th 9 p.m., the barometer read 751^{mm} with wind NE (force 6) shifting afterwards during the night by S to SW, the glass rising all the time. The centre of the Typhoon entered into the Japan Sea through the strait of Korea, as it is evinced by the observations made at Fusan on the Korean coast of the strait, compared with those made at Nagasaki. At Fusan, on the 13th. wind NE (force 2) on the 14th NE 3-6; on the 15th. NNE (force 8-6); the first observation, on the 14th. 6 a.m., gives the lowest reading mentioned, 753^{mm},7. The Typhoon was already partly overwhelmed by the depression, come from China, that at the same date occupied the north of the Japan Sea, between Yeddo and the Siberian coast. As this last storm passed over the Japanese Island to make away rapidly into the North Pacific, the Typhoon became divided into two fragments, the first of which went up the Japan Sea, while the other crossed Nippon, near Kioto on the 15th.

On the 16th and 17th the centre of the later made a short excursion to the South, then came back along the coast. On the 18th, 2 p.m., it passed close to the gulf of Yeddo (barom. 748^{mm}), causing violent winds from N and NW all over Japan. Here the track still seems to have turned in a ring before going on running along the east coast of Nippon. At Nobiru (lat. 38°) north of Tokio, on the 19th, the wind was blowing from North (force 6), barometer 747^{mm}; at Tokio wind NW (force 6) barometer 749^{mm}. At 2 p.m. the centre had yet approached nearer to the Island: at Myako, barom. 746^{mm}, wind light from W, while at Nobiru, somewhat lower down, wind raged from NW (force 10) barom. 748^{mm}. On the opposite coast the winds, equally violent, were also from W, and consequently bearing straight to the centre of the storm.

2°. Typhoon of the 15th October 1885.

This is another very instructive instance of a Typhoon well suited to set forth the first origin of most, if not all, of the Typhoons of the Philippine Islands. It was in Japan again that it sprang up. Issuing thence, on the 9th October, its was signalled, on the 13th, as lying east of Luzon; it then ran up again to its starting point, which it reached on the 16th, after having, the day before, displayed all its fury off the southern coasts of Japan.

Though our 6th map shows it as coming from Central China, I point to Japan as its birth place, because there had been a division taking place just as the centre of the depression entered the Pacific, and it was one of the fragments, which, like so many others, made away southward to the open sea, and rapidly grew into a violent Typhoon.

For the first part of the course of the storm come from China, there is nothing worth noticing, except that its passage at a short distance north of Shanghai was accompanied, in the afternoon of the 5th, by a thunderstorm which broke out in the South and made away towards the SE.; the next day, at 0h.45 p.m., squall from NW veering to N, preceded by strong WSW winds. The minimum of the barometer, 754^{mm}.58, observed at 3h 40 p.m. was very sharp, and clearly indicates the existence of a secondary whirlwind within the principal depression: from 3h to 3h.40 p.m. the barometer fell by 1^{mm}.6.

The centre of the storm entered into the strait of Korea during the night of the 6th-7th: minimum of the barometer at Fusan 752^{mm}, wind NNE (force 8) shifting on the morning to NW. It is of great interest to ascertain by the *Weathermaps* of the Tokio Observatory the absolute convergence of the winds from both sides of the Strait on the 7th 6 a.m., while the centre lay in the middle of it: on the Korean coast, the wind blew from NW; on the Japanese side, from SE. A part of the depression having passed to the south of the Archipelago as early as the 6th, the principal body crept up in the Japan Sea along the west coast; but there, in spite of the great proximity to the centre, the wind kept moderate. It was the presence of those low pressures detached on the other side of the Archipelago, that kept the storm so long close to Nippon, and made it describe, on the 9th, the circular path which is to be seen on our map, at which time the division was effected into two distinct whirlwinds which separated after crossing the Island. This passage across the Island took place on the 9th early in the morning, by 39° lat. At 6 a.m., Nippon lay between the two centres. At 2 p.m. the foremost of the two hastened on its course southward, while its fellow, in its turn, entered the Pacific, but lingered close to the eastern coast for some time, evidently detained by the action of its companion in the offing.

This latter, thanks to the considerable development it soon took at sea, can be followed, on the 10th and 11th, on the Japanese *Weathermaps*. The map of the 11th, 9 p.m. alone has no reference to it: all over the Archipelago the sky is clear and the barometer high, with a centre of high pressures on the very centre of Nippon; this is one of the few instances when the usual indications of "Low" and "High", in reference to the barometer, find no room on those maps. This particular circumstance enables us to estimate the diameter of the Typhoon at that hour in the direction of Japan: the centre lay about 31° lat. N and 135° long. E, at a distance of from 950 to 1000 miles from the edge of the cyclone on Japan. At

Manila, on the 11th, the barometer which, on the day before at 4 p.m., stood high, began to fall, wind WSW (force 1); there was also a fall at Formosa, and on the coast of China. In Japan, as early as the 12th 6 a.m., the *Weathermaps* showed the existence of low pressures in the South, a first indication of the Typhoon being about to turn northward, after having somewhat approached the Philippine Islands.

On the 13th October, a telegram was received at Hongkong from Manila, stating that there was a Typhoon East of Luzon: in fact the barometer gave a minimum of 756^{mm}.1 at 4 p.m., with WNW wind (force 4), the centre being far off at sea.

If the course kept by the Typhoon after the 13th were considered alone, without any knowledge of its previous motions, one might suppose it had come from the SE of Luzon and ascribe to it the classical *parabolic track*. But fortunately for the sake of truth and of the progress of nautical meteorology, to the indications of the Tokio *Weathermaps* I am able to add a very significant document. — On the 10th of October, that is only three days before the proximity of a Typhoon was first noticed at Manila, the British ship *Duke of Abercorn*, from Australia, lay by 11°.11' lat. N and 157°.44' long. E, that is to say about the spot where the centre might well have been laid out if the Typhoon had originally issued from regions south-east of Manila, whose latitude it reached on the 13th. Now the Captain's report states that, from the 10th to the 15th, the voyage so far as the Marian Islands (Saipan Island passed on the 15th) was effected with light N and NE winds and a very hot weather. This is inconsistent with the existence of a Typhoon in the same parts: we must then again look for its starting point somewhere else.

There is all probability that the fierce squall which, from the 11th to the 14th, traversed the North of China and on the 13th raised a true storm on the Gulf of Pechili, contributed not a little to check the Typhoon in its course towards the Equator, and to call it back to the North. Some particulars about that northern storm may be of interest.

— Captain Th. Shaw of the S.S. *Chung-king* sent me the following report: "October 13th 1 p.m.. "River Pei-ho (Tientsin river): heavy squall came down from NW with heavy rain. Just before there "were a great number of small whirlwinds driving across the plain and throwing the sand up in the air "100 feet. The weather previous to this had been unusually mild for the season. Midnight, had a strong "gale from NNE in the Gulf of Pechili with a heavy sea".

— The S.S. *Pautah* left Tientsin on the 13th 9 a.m. and passed Taku at 6 p.m. when a strong northerly gale with high cross sea was encountered, causing the ship to strain and labour heavily and take on board large quantities of water. On the 14th the gale continued; at 2 a.m. a heavy sea came on board and carried away the port side of the pilot-house. With such fury did the water strike the ship, that the panes of glass, half an inch thick, were shattered, and pieces of it which were hurled against the back of the pilot house and tore out large splinters of wood.

— The sailing ship *Faugh Balaugh*, Capt. Rüte, in the Liao river (Newchwang river) had a barometric maximum (767^{mm}.8) on the 12th 8 p.m., the wind being NE by N (force 4): on the 13th noon wind N (force 3); at 3 p.m. calm, lowest reading of the barometer 762^{mm}.0; then the wind, blowing again from NE by N, increased to force 8 (6 p.m.). Next day storm raging all day, wind keeping between NE and N (force 9): barometer rising up to 770^{mm}.1 at 10 p.m. — The centre of the storm passed near Newchwang, to the South, and made away towards the Japan Sea, where we shall find it again on the 15th and 16th standing out, as it were, against the Typhoon itself over Nippon Island.

The foregoing extracts have been given to show the nature of those continental depressions, whose depth is generally not in proportion with the strength of wind. The present one spread its influence down to Zi-ka-wei, where a barometrical minimum took place on the evening of the 13th with easterly winds hauling round in the night to N and NNW under the preponderating action of the Typhoon, whose passage at a great distance had no effect but to retard the rising of the barometer.

Farther South, on the coast of China and at Formosa, it was on the 14th that the Typhoon, already advancing northward, made its presence be felt, but only by moderate winds and a slight fall of the barometer.

It was however fully formed, ready to vent its fury and spread havoc far and wide.

The first ship that, as far as I know, underwent the violence of the Typhoon, was the British barque *Areola,* Capt. Peregrine. There are some particulars worth noticing in the report the Captain kindly sent me, while in harbour at Shanghai: "On the 14th, noon, lat. 26°42' — longit. 133°0, wind ESE strong, cloudy weather; — 4 p.m. wind increasing, heavy sea making from the South : barometer going down very gently; — 6 p.m. barom. 754^{mm}.4, wind ESE increasing, with rain, ship running 6 knots to WNW: — 10 p.m. hove to on port tack, wind ESE with heavy sea from SE. — Midnight on the 15th, heavy gale from SE with rain: barom. 741^{mm}.7; ship under bare poles. After this time the glasses fell more rapidly, rain more dense; the force of the wind is now something frightful. By 9h.30 a.m. the aneroid had fallen so low, that the hand rested on the thermometer tube and could not fall further; but the marine mercurial barometer registered 696^{mm} at 9h.45 a.m.: then the wind was veering gradually round by the S and SW; at 10h.30 a little lull in the wind; suddendly it shifted round to W, and the glass began to rise rapidly; — 4 p.m. wind WNW to NW blowing very hard. Position at noon: lat. 27°.0' — longit. 132°.0".

That enormous fall of the barometer (nearly 70 millimetres in a few hours) seems to be unquestionable; for comparison twice made at Shanghai with the barometer of the Zi-ka-wei observatory, on November 6th and 17th, a month after the Typhoon, showed the good quality of captain Peregrine's mercurial barometer. The very centre of the Typhoon having passed over the *Areola,* the position of that ship between 10 and 11 a.m. on the 15th October gives us a certain point of the track, viz lat. 27° — longit. 132°.

The American S.S. *City of Peking* had left Yokohama on the 14th bound for Nagasaki. On the 15th, at noon, by 32° lat. and longit. 134°, heavy SE swell and storm began to blow with NE wind veering to N and then to NW. Barometric minimum 740^{mm}.4 probably about midnight on the 16th. During the gale, both quarter boats were washed away.

On the 15th the German ship *Anna* left Hiogo, sailing to the South-west. A heavy WSW swell was setting in, the wind fast increasing, barom. 751^{mm}.8. Sail was gradually reduced; by 8 p.m. the ship was under lower topsails. Hove to on the starboard tack in order to keep out of the influence of the Kuro-Siwo (great current of Japan). About 9 p.m. a terrific squall struck the ship, throwing her on her beam-ends, and as she showed no signs of righting, Captain Hellmers ordered the main lower-topsail sheets to be slackened away. About midnight, on the 16th, the barometer showed the lowest record 732^{mm}.8. After 2 a.m. the wind moderated, and the weather cleared up with a fresh NW breeze.

At the very hour when the *Anna* had her minimum, a steamer, the *Bellona,* that had left Kobe on

the 15th at 6 a.m. for Shanghai, was enveloped in the Typhoon, and had as minimum of her barometer 737^{mm}; damage on board; chief officer lost, second and third mate, carpenter and two sailrs hurt.

We cannot insist too much upon the danger of an unlimited confidence in the theory of the circular rotation of the winds in a cyclone, particularly near a coast. The foregoing pages contain two striking illustrations of that remark; another still more remarkable is that of the French Frigate the *La Galissonnière*: this armour-clad ship bearing the flag of Rear-admiral Lespès and sailed by Post-capt. Fleuriais, was approaching Yokohama. On the 15th 10 p.m., all signs of a Typhoon coming on were observed: barometer falling pretty rapidly; wind from ENE freshening. Before entering into any explanations, I think it advisable to transcribe in full the observations of Post-captain Fleuriais. The *La Galissonnière* is provided with a Robinson anemometer fixed at the top of one of the masts, and with a self-registering barometer, of Richard's system. The commanding officer, after noting with his own hand the winds observed every hour, opposite to the corresponding variation of the barometer, and adding many valuable remarks, had the good idea of multiplying by photography the very sheet of the registering instrument, a copy of which he sent to me. Here are then particulars drawn from that authentic document.

French Frigate **LA GALISSONNIÈRE**
80 miles to the S 42° W of Yokohama.

Date	Hours	Barometer	Wind *Direction*	Wind *Velocity* (in metres per second of time)	Remarks
		mm			
October 15th	noon	759.5	SE	1 - 7	
	4 p.m.	59.0	NE	9	
	8	57.3	NE	2	
	9	56.2	ENE	9	
	10	55.0	ENE	27	
	11	54.0	ENE	29	Close-reefed.
16th	midnight	52.5	ENE	29	
	1 a.m.	50.0	ENE	30	
	2	48.5	ENE	35	
	3	45.5	ENE	37	
	4	41.0	ENE	38	
	5	38.0	ENE-ESE	40-45	Enormous sea — Three boats washed away.
	6	33.0	ESE-E	46	— Waves 14 to 15 metres high.
	7	39.0	E-NE	46-40	
	8	44.0	NE-N	40-35	
	9	48.0	N-NNW	28	
	10	48.0	NNW-NW	8	Proceeded again.
	11	51.5	WNW-W	8	
	noon	52.5	WNW-W	8	
	1 p.m.	54.0	W	8	
	2	54.8	W	8	
	4	56.5	W	4	
	6	59.0			
	8	60.8	ESE	5	Anchored at Kaneda.

Now, if the path followed by the Typhoon from the 15th 10 a.m. to the 16th noon, be considered, we find it to be a regular curve having its apex, about 7 a.m., somewhat to the SW and not far from the position of the *La Galissonnière*. The direction of the Typhoon seems to have varied as follows:

On the 15th	about	noon	N 30° E
16th		midn.	N 45° E
,,	6	a.m.	N 56° E
,,		noon	N 67° E

An attentive comparison of these observations with the *Tridayly Weathermaps*, of the Tokio Observatory, seems to prove unquestionably that the centre of the Typhoon passed, on the 15th between 7 and 8 a.m., to the South-east of the Japanese coast and about 80 miles from it. Since the *La Galissonnière* had the maximum velocity of wind simultaneously with the barometric minimum, she must have

been far from reaching the central region. We may well regret to be deprived of the interesting remarks that such a well-informed man as the commanding officer of the Frigate would, no doubt, have made on the phenomena peculiar to that region; we find however in his report ample matter for instruction.

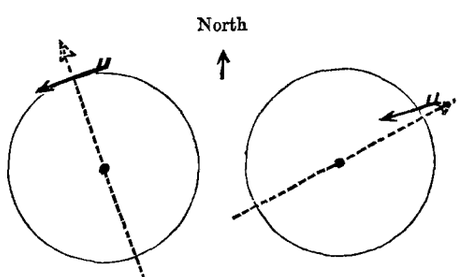
The main point on which we must fix our attention is the direction of the winds in the part of the Typhoon passed through by the *La Galissonnière*. In order to ascertain all the particulars of the case with all possible accuracy, the track has been drawn on a large scale and the bearings of the centre to the ship taken for every hour. Herewith those positions together with the angles of the direction of the wind with the radius drawn from the ship to the centre.

LA GALISSONNIÈRE

Dates	Hours	Bearing of the centre of the Typhoon.	Angle of the wind with the radius.
October 15th	midn.	S 39° W	Calm
	noon	,, 39 ,,	26°
	4 p.m.	,, 43 ,,	2
	9	,, 43 ,,	24
,, 16th	midn.	,, 40 ,,	27
	3 a.m.	,, 32 ,,	25
	4	,, 25 ,,	42
	5	,, 15 ,,	75
	6	South	90
	7	S 34° E	102
	8	,, 66 ,,	88
	9	,, 83 ,,	72
	10	N 88 E	58
	11	,, 83 ,,	41
	noon	,, 80 ,,	21

Very different indeed are these results from what Buys-Ballot's law, strictly interpreted, would require : *Face the wind, and the centre of the Typhoon is at your right hand;* that is to say, the angle made by the wind with the radius of the storm should always be an angle of 90°. The investigation of the West Indies Hurricanes, of the Bengal and Indian Ocean Cyclones, and of the Atlantic Storms, has led to modify the law in so far that the angle of the wind with the radius is generally smaller than 90°: the directions of the winds are not tangent to the circle, but inclined on it, or converging towards the centre of the Cyclone. In all my publications on the subject of China Sea Typhoons, I have always insisted on this important point, and I wish the present essay on the Typhoons of 1885 may not be without its utility in uprooting the prejudices that still remain in the mind of a number of seafaring men.

What danger might not the commanding officer of the *La Galissonnière* have run into, had he had an unbounded trust in the theory of the *circular winds!* Steady winds from ENE, increasing more and more would have led him to suppose that the Typhoon, coming from SSE, was to pass right over the ship (fig. A), while in fact the track ran from WSW to ENE, (fig. B) the wind making an angle of only 30° to 40° with the radius of the circle.



A. Tangential Wind
Erroneous track

B. True track
Convergent Wind

Now if the foregoing table be carefully examined, a very important fact is elicited, viz. the gradually increasing value of the inclination of the wind, to the moment of the greatest proximity of the centre, and again the decreasing value of that inclination as the Typhoon was making off. This complication rather increases the difficulty for the mariner, and requires his most serious attention. In the supposition of circular or tangential winds, the manœuvring for keeping off a cyclone seemed easy enough, and only required coolness and patience; but in the case of furious winds rushing almost straight and impelling the ship headlong towards the very centre of the Cyclone, as it was certainly the case with the *La Galissonnière,* would it be safe strictly to follow the old rule—particularly at the beginning of the storm, when prudence commands to avoid it, unless there be a fair hope of profiting by it to make headway? On the inner and most dangerous parts of the cyclone, the old rule must assuredly be strictly adhered to: for there the circular motion of the winds is a reality: but is it not rather late first to know what is to be done, when a raging sea and furious wind hardly allow of any manœuvring at all? The greatest caution therefore is required, particularly in the vicinity of land, where the winds often prove remarkably convergent: let every one prudently take into account what experience enlightened by observation has taught him, and also, by carefully recording the facts observed, contribute his share in ascertaining the laws of those great natural phenomena, that a general rule, safe and always reliable, may at last be drawn up.

Lastly, let us notice the transient divergence of winds immediately behind the centre. This may perhaps be due to their extreme violence, to a lengthening of the central region, or again to the same cause which, in Japan, made the Typhoon pass quite close to the coasts of the Archipelago without being felt: that cause was the presence, in the Japan Sea, on the opposite side of the Island, of the Chinese depression above alluded to: it had recalled from South to North the Typhoon making towards Luzon, it now kept it at a distance, off Nippon, neutralizing its winds, and calming its fury. The two maps of the 15th 9 p.m. and the 16th 6 a.m set off that depression clearly, near the western coasts, which it followed up on a path parallel to that of the Typhoon.

Thus, even the observations of the *La Galissonnière* alone show that the winds in the present Cyclone, far from describing circles round the centre, blew more or less direct to that point; being absolutely convergent near the borders of the region invaded by the storm, while the angle they made with the radius of the circle increased as the distance to the centre diminished. At the shortest distance, the storm being at its worst, the winds were truly tangential. As the cyclone made away, the convergence was observed again in its hind part with the same variations as in the fore part. The winds thus were blowing in spiral curves.

Storms of 22d-26th and 24th-26th October 1885.

The importance of the facts brought out in studying the Typhoon encountered by the *La Galissonnière,* leads me here to make a short digression on certain consequences of the enormous convergence of the winds in large Cyclones; moreover the two storms recorded in our 7th map will furnish me with an opportunity of showing how the constitution of Typhoons, or true *Cyclones,* differs, from that of Storms, or simple depressions issued out of the continent of Asia.

Since winds are nothing but currents of air moving more or less rapidly through the atmosphere, it is evident that, if such currents converge from all parts towards the centre of a Cyclone, where the pressure, far from being increased by this afflux, is on the contrary lower than in any part of the periphery of the whirlwind, those winds must find a passage above always open to let out the huge masses of air incessantly arriving below. In a word, the *air ascends in spires round the axis of these whirlwinds*. Now, since whirlwinds are localized, independent as it were of the remainder of the atmosphere, it is clear that they must find in themselves the conditions of their existence, and in order incessantly to recruit the afflux of air towards the centre, the masses of air carried upward, must needs come back towards the borders of the system, thence to rush down and enter into circulation again. This constitution of the great Cyclones, made manifest by the convergence of the winds in the rear as well as in front of the centre, does not seem to be exactly that of the *Storms* or ordinary atmospheric depressions. Within those vast whirling masses, which are found in the temperate regions, generally moving from West to East, there may be observed, as in the tropical Cyclones, an energetic suction taking place at a moderate altitude where the aerial currents have the greatest velocity, and consequently in the lower strata there is also a draught both towards the centre and upward: but that suction seems to take place only on the fore part of the whirlwind, where the winds are lighter, very convergent, warm, moist and accompanied with a fall of the barometer: they are ascending, and their inclination upward goes increasing to the moment of the barometric minimum. This point once reached, and the centre having passed to the North of the station of the observer, things soon bear another aspect. The wind blows in squalls between W and NW, the thermometer falls, while the barometer rises, usually much faster than it had fallen, and the wind becomes suddenly inclined downward, a fact that gives it a peculiar character of fury well known to seamen. Thus it would seem that the vertical currents rushing from above downward are to be sought for, not on the periphery or in the fore part of the depression, but precisely in the hind part, which generally speaking is less extensive than the fore part. Such then, it appears, is the difference between the two kinds of aerial whirlwinds: the violent sea *Cyclones* that meet with but few or no obstacles to their regular development, and the continental *Storms* or those which move near land, not so free in their evolutions.

Here, some one may stop me, and ask for proofs of what I put forward with such bold assurance: an assurance however which is not unjustifiable, being founded upon incontrovertible facts.

The study of Typhoons and Storms in the Far-East, which has become, almost of a necessity, the principal object at the Zi-ka-wei Observatory, has long since called my attention upon the vertical motions of the air. The absolute ignorance that prevailed in that respect, though such a phenomenon be of great importance in meteorology, led me to devise a means, an instrument if possible, to indicate what is taking place in the vertical direction. As early as 1880, I had imagined a *Vane* especially fitted for that kind of researches: but, in spite of various modifications, it never gave quite satisfactory results. Later on in 1884, I imagined to seek the solution of the problem in a different way, viz. by the use of a revolving anemometer. I will not waste time here in describing all the variations of forms that the instrument had to undergo, this will be the matter of a special paper; I will only say that it keeps perfectly at rest in an *horizontal* current of air, however violent it may be; it revolves only under the action of the vertical component of the wind, turning one way when the air is ascendent [what I call positive

motion (+)], and the other way with a descending current [negative motion, (–)]. That anemometer has been fixed in its post of observation at 41 metres (123 feet) above the ground, 8 metres (24 feet) above a narrow platform which forms the top of a wooden pyramidal tower erected at Zi-ka-wei with the view of urging my researches with better chances of success. This altitude, to be sure, is but very small for observations of this kind; and yet, the great motions taking place in the high regions of the atmosphere cannot fail to exert an action on the inferior strata, to make them swell or collapse. Observations registered for more than one year, superabundantly prove that such actions are far from being insignificant. I will here give two or three examples.

The 7th map gives the tracks of two simple storms, the first over Japan, the second across China: both caused the barometer at first to fall, then to rise again. The following is a table summing up the observations relative to those two centres of depression.

		Number of revolutions of the anemometer +	Number of revolutions of the anemometer –	Ratio of + to –	Inclin. of wind calculated	Barometer daily means.	
October	22d	7290	529	12	4°.06	766.8 mm	Distant storm
	23	7990	16	50	5.10	764.2	
		means					
October	24 / 25	11495	243	47	6°.12	762.7 mm	Storm in the neighbourhood.
	26	5610	439	13	5.66	765.5	

These two storms did not offer any interesting particulars in the present point of view; they are only quoted because they occurred just after the Typhoon of the *La Galissonnière* which was the occasion of speaking of the *Inclination* of winds as a consequence of their convergence in Cyclones. Now, I will state what I found as means of the 12 storms of October and November: while the barometer was falling, that is to say while the centre of the storm was approaching, ascendent winds were to descendent in the proportion of 49 to 1; at the time the barometer was rising, that is while the storm was making away from the station, the proportion decreased to 9 : 1.

Ascendent winds considered alone, were on an average twice more frequent before than after the passage of the storms; on the contrary descendent winds were 26 times more frequent after than before the barometric minimum.

These new observations contribute, I think, to throw additional light on all those grand movements of the atmosphere, and could not be passed over in the present essay.

LAST TYPHOON OF THE YEAR 1885.

October 29th — November 13th

This Typhoon, being the only one of the present year that crossed Luzon, and came pretty close to Manila, would deserve a more extensive study. But the documents that have come to hand, though sufficient to lay out its track, are not numerous nor circumstantial enough to allow of a complete description.

On October 29th, about 3 p.m., a centre of depression was at sea somewhat to the North of Shanghai, and became divided into two whirlwinds: the one passed into the Japan Sea over Korea, the other leaving Japan to the left of its track made away in the South-east: the Japanese *Weathermaps* leave no doubt as to that last direction, which is of particular interest for us. I will then only refer to those maps for further particulars.

At Manila, on October 30th and 31st, the winds were light and variable. From November 1st, they settled about W: first WNW on the 1st and 2nd, then to W on and after the 3rd. The barometric maximum, 762^{mm}, took place only between the 4th and the 5th, which gives to the Typhoon itself a rather inconsiderable diameter, as might have been expected in such a low latitude.

			Barom.	Wind	
			mm		
November	6th	4 p.m.	758.2	N	2
	7th	10 a.m.	55.4	NW	4
		4 p.m.	49.3	WNW	7
	8th	10 a.m.	58.7	S	3
		4 p.m.	56.9	SW	5

The Typhoon crossed Luzon on the evening of the 7th, at a short distance North of Manila, running westward. It exerted a considerable violence on the eastern coasts of the Archipelago, and a correspondent wrote to the Manila paper *El Comercio,* that in the province of South-Camarines, to the South-east of the capital, there were 828 substantial houses thrown down, and 3544 Indian huts destroyed; 13 churches, 10 convents etc... are but heaps of ruins; 12 persons were crushed to death, six others had disappeared.

From the 8th down to the 22nd, weather bad on the China sea; numbers of ships suffered on the voyage from Singapore or Saigon to Hong-kong. This was due to our Typhoon, which had taken its stand there as on a scene where, on account of its small size it could move at ease.

CONCLUSION.

It was in 1877 that the series of investigations relative to the Typhoons of China was commenced at the Zi-ka-wei Observatory: since then every year has brought a rich harvest of facts, and also greater facilities for such researches. Accordingly we are no more reduced to the vague determinations of the direction followed by the Typhoons of the China Sea given by Piddington; besides, a connection has been established with the Cyclones of the various seas, where they had been observed by other meteorologists. They have proved to be as quick in their motions, as unstable, and as sensitive to reciprocal action, as the simple continental depressions.

Between the tropics the Typhoons are found usually running from East to West; in the temperate zone, they proceed from West to East; but there is an incessant exchange of storms between those two regions, and directions from North to South are as often to be met with, as the contrary. It is this last fact, already pointed out in the paper on the Typhoons of 1882, 1883 and 1884, that I have been anxious to bring into full light in the present essay on the Typhoons of 1885. It gives us the key of an apparently inextricable riddle, showing almost to a certainty the first origin of the Typhoons of the tropics and of the Philippines: *it is not in the Equatorial regions that the springing up and the starting point of those violent* Cyclones are to be looked for: they arrive there from upper latitudes already fully constituted; they generally issue out of Japan, where they had come from China in the shape of Storms.

Another point upon which we have had to insist with particular stress, is the danger of too strict an application of the laws of storms. The rules hitherto familiar to most seamen, were framed in the assumption that the winds have always a *circular motion* round the centre of the Cyclone. Now, according to the universal opinion of Meteorologists, the winds are not *circular*, or *tangential* to the circle of the storm, but they blow with a marked inclination on the radius of the circle: in short, they are convergent. This convergence, however, disappears in the region of the greatest violence, near the centre; there the winds are certainly circular, and even sometimes a little divergent, as I have shown as early as 1879 (Essay on the Typhoon of July 31st), and as it is well evinced by the observations made on board the *La Galissonnière* on the 16th October 1885. It follows that the manœuvre to keep from being carried to the centre of the Typhoon is more complicated than it appeared at first; the rule to be drawn up must take into account the various inclinations of the wind on the radius of the circle.

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