PHILOSOPHICAL TRANSACTIONS.

X. *Observations upon the Marine Barometer, made during the Examination of the Coasts of New Holland and New South Wales, in the Years* 1801, 1802, *and* 1803. *By* Matthew Flinders, *Esq. Commander of his Majesty's Ship* Investigator. *In a Letter to the Right Hon. Sir* Joseph Banks, *Bart. K. B. P. R. S. &c. &c. &c.*

Read March 27, 1806.

Isle of France, Aug. 19, 1805.

A FORE-KNOWLEDGE of the wind and weather is an object so very interesting to all classes of men, and the changes in the mercurial barometer affording the means which appear most conducive to it, a system that should with certainty explain the connection between the variations of the mercury and those in the atmosphere under all circumstances, becomes greatly desirable; to seamen, more especially, whose safety and success depend so much upon being duly prepared for changes of wind, and the approaching storm, it would be an

acquisition of the first importance: in a more extended view, I may say, that the patriot and the philanthropist must join with the philosopher and the mariner in desiring its completion. So long and widely-extended a course of observation, however, seems requisite to form even a basis for it, that a complete system is rather the object of anxious hope than of reasonable expectation. Much has been done towards it, but so much appears to remain, that any addition to the common stock, however small, or though devoid of philosophical accuracy, I have thought would be received by the learned with candour. With this prepossession, I venture to submit to them some observations upon the movement and state of the mercury upon the coasts of New Holland and New South Wales, the Terra Australis, or Australia, of the earlier charts.

The principal circumstance that has led me to think these observations worth some attention, is the coincidence that took place between the rising and falling of the mercury, and the setting in of winds that blew from the sea and from off the land, to which there seemed to be at least as much reference, as to the strength of the wind or state of the atmosphere; a circumstance that I do not know to have been before noticed. The immediate relation of the most material of these facts, it is probable, will be more acceptable than any prefatory hypothesis of mine; and to it, therefore, I proceed; only premising, that a reference to the chart of Australia will be necessary to the proper understanding of some of the examples.

My examination of the shores of this extensive country began at Cape Leuwen, and continued eastward along the south coast. In King GEORGE's Sound, December 20, 1801,

after a gale from WSW, the mercury had risen from 29,42 to 29,84, and was nearly stationary for two days, the wind being then moderate at NW, with cloudy weather. On the 22d, the wind shifted to SW, blew fresh, and heavy showers of rain occasionally fell; but the mercury rose to 30,02, and remained at that height for thirty hours; and on the weather clearing up, and the wind becoming moderate in *the same quarter*, it rose to 30,28.

Fresh breezes from E and SE caused a rise in the barometer in King GEORGE's Sound, once to 30,20, and a second time to 30,18, although the weather at these times was hazy; but with light winds from the same direction, which were probably local sea breezes only, the mercury stood about 29,95 in that neighbourhood.

2d Example. Jan. 12, 1802, in D'ENTRECASTEAUX's Archipelago, the mercury rose to 30, 23, previously to a fresh breeze setting in from the eastward. In the evening of the 13th it blew strong from ESE, with hazy weather, and a rapid fall of the mercury to 29,94 had then taken place; but instead of the wind increasing, or bad weather coming on, the wind died away suddenly, and a light breeze came off the land at midnight, with cloudy weather.

At the Cape of Good Hope, which is nearly in the same latitude, the mercury rises with the fresh gales that blow there from the SE in the summer season. The weather that accompanies these south-east winds, is nearly similar in both places; the atmosphere being without clouds, but containing a whitish haze, and the air usually so dry as sensibly to affect the skin, particularly of the lips.

3d. Jan. 22. Three degrees east of the Archipelago, the

mercury fell with some rapidity down to 29,65 with the wind from ESE. It was eight o'clock at night, and we prepared for a gale from that quarter; but at ten, the wind suddenly shifted to WNW, coming very light off the land. On its veering gradually round to SSW, clear of the land, at noon, 23d, it freshened, and the weather became thick; yet the mercury had then risen to 29,84, and at eight in the evening to 29,95, though the wind then blew strong. It continued to rise to 30,16 as the wind shifted round to SE, and fine weather came on; but on the wind passing round to ENE and NNE, which was off the land, the mercury fell back to 29,73, though the weather was fine and the wind moderate. On a sudden shift of wind to the SW, a fresh breeze with hazy weather, it again began to ascend, and a similar routine of wind, producing nearly the same effects upon the barometer, again took place. The effect of sea winds in raising the mercury, in opposition to a strong breeze, and of land winds in depressing it, though they were light, was here exemplified in two remarkable instances.

4*th.* In the neighbourhood of the Isle of St. FRANCIS of Nuyts, longitude $133\frac{1}{2}°$ east of Greenwich, we experienced a considerable change in the barometer. For nine days in January and February the wind continued to blow constantly, though moderately, from the eastward, mostly from the SE. It appeared like a regular trade-wind or monsoon, but so far partook of the nature of sea and land breezes, as commonly to shift more to the southward in the day, and to blow more from east and NE in the night. The weather was very hazy during these nine days; so much so, that for six of them no observation of the sun's altitude, worthy of confidence, could

be taken from the sea horizon, although the sun was sufficiently clear; and in the whole time, the mercury never once stood so high as 30 inches, but was frequently below 29,70. I considered this to be the more extraordinary, as settled winds from the eastward, and especially from SE, had before made it rise and stand high upon this coast, almost universally, even when there was a considerable degree of haze. The direction of the south coast, beyond the Isle of St. FRANCIS, and even abreast of it, was at that time unknown to me; but I then suspected, from this change in the barometer, that we should find the shore trending to the southward, which proved to be the case. The easterly winds, then, whilst they came off the sea, caused the mercury to rise upon the south coast; but in this instance that they came from off the land, they produced a contrary effect; but it is to be observed, that the most hazy part of the time, and that during which the mercury stood lowest, was two days that the wind kept almost constantly on the north side of west, more directly off the land: its height was then between 29,65 and 29,60.

The haze did not immediately clear away on the wind shifting to the westward; notwithstanding which, and that the new wind rose to a strong breeze, and was accompanied with squalls of rain, the mercury began to ascend, and had reached 29,95 when the squalls of wind and rain were strongest; the direction of the wind being then from SSW. On its becoming moderate, between SSW and SSE, the mercury ascended to 30,14, and remained there as long as the wind was southwardly.

5th. Going up the largest of the two inlets on the south coast, in March, we were favoured with fine fresh breezes

from SSW to SSE, sometimes with fine, sometimes with dull weather, the mercury rising gradually from 30,08 to 30,22. In twenty-four hours afterwards, it fell below 30 inches, and a light breeze came from the northward, off the land, with finer weather than before. The mercury continued to fall to 29,56, where it stopped; the wind having then ceased to blow steadily from the northward, and become variable. In twenty-four hours more, the wind set in again to blow fresh from the southward, the mercury having then returned to 29,94, and it was presently up to 30,22 and 30,28. It kept nearly at this height for several days that the southwardly wind blew fresh, but on its becoming lighter, and less steady in its direction, the mercury descended; and in the calm which followed, it had fallen to 29,90. This example affords clear proof of a fresh wind from the sea making the mercury rise, whilst a light wind off the land, with finer weather, caused it to descend.

6th. The calm was the prelude to a fresh gale; but the mercury began to rise at eight in the evening when it had just sprung up; by the next noon it was at 30,10 when the wind blew strongest, and in the evening at 30,22. This gale began as gales usually, if not always, do upon this coast, in the north-west quarter, and shifted round to SW and SSW; but quicker than I have generally seen them: there was no rain with it, nor was the atmosphere either very hazy or cloudy.* The mercury continued to rise till it had reached 30,25, and then was stationary as long as the wind remained between south and west; but on its veering round to the

* I afterwards learned from Captain BAUDIN, that this gale was much heavier in Bass' Strait than we felt it at Kanguroo Island.

eastward of south, a second rise took place, and for forty hours the mercury stood as high as 30,45, the wind being then between SE by S and east: the weather was very dull and hazy during the first half of these forty hours, but finer afterwards. As the winds between SE by S and east slanted off the main land, this example seems to be in opposition to the 4th, and leads me to think, that it might have been the very extraordinary kind of haze, and perhaps some peculiarity in the interior part of the land abreast of the Isle of St. FRANCIS that in part occasioned the fall of the mercury with south-east winds; as much, perhaps, as the circumstance of the wind coming from off the shore.

After this rise in the mercury to 30,45, it fell gradually; but, for thirteen days, kept above 30 inches, the winds being generally between SE and SW, but light and variable, and the weather mostly fine.

7th. North-eastwardly winds, off the land, were the next that prevailed; they were light, and accompanied with cloudy weather and spitting rain. The mercury fell to 29,70, and remained there till the wind shifted to the west and southward, when it began to rise, and in two days was up to 30,42. At that time we were off the projection marked II in the chart, in $139\frac{1}{2}^{\circ}$ east longitude; the wind had then veered to the south-eastward along the shore, with a steady breeze, and the mercury remained nearly stationary so long as it lasted; but on the wind dying off, and flawing from one side and the other, it descended quickly to 30 inches. A breeze then sprung up at NW, which, within twenty-four hours, shifted suddenly to SW, and blew a gale which had near proved fatal to us. It was accompanied with rain and very

thick weather, and lasted two days; by which time, the mercury had descended to 29,58.

8*th.* In Bass' Strait, for several days in the month of April, the mercury stood above 30,40 with the wind from the south and eastward, sometimes blowing fresh: the weather generally fine. It then fell half an inch in eight hours, and a wind set in soon after from the north-westward which continued four days, blowing moderately, with cloudy weather, and sometimes a shower of rain; the mercury remaining stationary between 29,83 and 29,89. On this second wind dying away, a strong breeze sprung up which fixed at WSW with squally weather; but for three days no alteration took place in the barometer, until the wind shifted to NW and north, and the mercury then descended to 29,52, though the weather was finer, and wind more moderate than before.

9*th.* Passing along the south coast of Australia the second time, we experienced light winds from the sea for forty hours in D'ENTRECASTEAUX's Archipelago, in the month of May: they were variable between WSW and SSE with dull cloudy weather, and the mercury stood very high, being up to 30,50 most of the time. The wind then came round to N by E and NNW; previously to which, the mercury began to descend, and it kept falling for two days till it reached 30,19, though the weather was not so cloudy as before, and the wind was equally light. On the wind veering to west and WSW the mercury rose to 30,25; but it now came on to blow fresh, with squally thick weather, yet the mercury continued nearly stationary for twenty-four hours, appearing to be kept up in consequence of the wind having shifted round to SSW, more directly from off the sea. On its increasing to a

gale, however, there was a pretty rapid descent in the barometer to 29,96; but the ascent again was equally rapid, and to a greater height, on the wind becoming moderate. In a short calm that succeeded, the mercury stood at 30,42, but on the wind setting in from the north, which was from off the land, it fell to 30,25, and remained there two days: we had then reached Bass' Strait.

From these examples upon the south coast, it appears, generally, that a change of wind from the northern, to any point in the southern half of the compass, caused the mercury to rise, and a contrary change to fall; and that the mercury stood considerably higher when the wind was from the south side of east and west, than, in similar weather, it did when the wind came from the north side; but, until it is known what are the winds that occasioned the mercury to ascend, and what to descend, upon the other coasts of Australia, it will probably be not agreed, whether it rose in consequence of the south winds bringing in a more dense air from the polar regions, and fell on its being displaced by that which came from the Tropic;—or whether the rise and higher standard of the mercury was wholly, or in part, occasioned by the first being sea winds, and the descent because those from the northward came from off the land.

The height, at which the mercury generally stood upon the south coast, seems to deserve some attention. It was very seldom down to 29,40, and only once to 29,42. Of one hundred and sixty days, from the beginning of December to May, it was nearly one-third of the time above 30 inches; and the second time of passing along the coast, from the 15th of May to the 1st of June, it only once descended to 29,96,

and that for a few hours only, its average standard for these sixteen days being 30,25. Upon the eastern half of the coast, beyond Cape Catastrophé, in March, April, and May, the mercury stood higher than it did on the western half in December, January, and February: the average standard of the first was 30,09, but that of the latter only 29,94. At the Cape of Good Hope, the mean height in the barometer, during eighteen days in October and November, was 30,07.

The marine barometer on board the Investigator, supplied to the astronomer by the Board of Longitude, was made by NAIRNE and BLUNT, and had, I believe, been employed in one or more of the voyages of Captain COOK, and perhaps in that of Captain VANCOUVER. I suspect, that it was not suspended so exactly in the proper place, as the later instruments of these makers probably are; on which account, the motion of the ship caused the mercury to stand too high; and perhaps one or two-tenths of an inch might be deducted with advantage from the heights taken at sea, but I think not when the ship was lying steadily at anchor in harbour. The barometer stood in my cabin, and the height of the mercury was taken at day-break, at noon, and at eight in the evening, by the officer of the watch; as was also that of the thermometer.

The general effects produced upon the barometer by the sea and land winds, on the east coast of Australia, will be learned from the following abridgment of our meteorological journal.

1st. In the run from Cape HOWE, in $37\frac{1}{2}^{\circ}$ south latitude, to Port Jackson, in 34°, once in the month of May, and once in June, I found that the mercury descended with light winds from north, NW, west, and WSW; whilst during fresh

breezes from south and SW it ascended, and stood considerably above 30 inches; with the wind at NE and NNE it also kept above 30 inches, but not so high, nor did it rise so fast, as when the wind was from SSW. From between south and east, the winds did not blow during these times. This example does not differ so much from those on the south coast as to be decisive of any thing.

2d. The observations made during a stay of ten weeks at Port Jackson, in May, June, and July, 1802, are more in point than almost any other. Strong eastwardly winds were very prevalent at that time, and were almost always accompanied with rain and squalls; yet this weather was foretold and accompanied by a rise in the barometer, and the general height of the mercury during their continuance was 30,20: higher if the wind was on the south side of ESE, and lower if on the north side of east. The winds from south and SSW, which blow along the shore, kept the mercury up to about 30,10, when they were attended with fine weather, as they generally were; but if the weather was squally, with rain, it stood about 29,95. During settled winds from between WNW and SW, with fine weather, the mercury generally stood very low, down at 29,60;* and what is more extraordinary, when these winds were less settled, and the weather dull, with rain occasionally falling, the range of the mercury was usually between 29,80 and 30,10; nearly the same as

* My friend Colonel PATERSON, F. R. S. commander of the troops at Port Jackson, in judging of the approaching weather by the rise and fall in his barometer in the winter season, told me, that he had adopted a rule directly the reverse of the common scale. When the mercury rose high, he was seldom disappointed in his expectation of rainy, bad weather; and when it fell unusually low, he expected a continuance of fine, clear weather, with westwardly winds.

when the wind was at SSW with similar weather; the reason of which may probably be, that at some distance to the southward these westwardly winds blew more from the south, and were turned out of their course, either by the mountains, or by meeting with a north-west wind farther to the northward.

The winds from north and NW blew very seldom at this time: the mercury fell on their approach.

To the state of the mercury during our second stay at Port Jackson, in July, 1803, and part of June and August, it is not in my power to refer, as I have not been able to obtain that part of my journal from General DE CAËN.

The effects of some winds upon the barometer in this 2d example, are considerably different to what they were upon the south coast. The wind at WSW or SW with fine weather, had always caused the mercury to rise and stand high, and those from the NE to fall; whereas here, the effects of those winds were almost directly the reverse. The winds from SSW, SE, and as far as east, made it rise on both coasts, with the exception of the 4th example on the south; and from between north and WNW the mercury fell in both cases and stood low.

3d. Steering along the east coast, from Port Jackson to the northward, in July, we had the winds usually between south and SW, and sometimes WSW, the mercury being nearly stationary at 30 inches; but meeting with a spurt of the south-east trade wind in latitude 24°, we found it rise to 30,30 for two days. A westwardly wind brought it back to 30 inches for a short time; but on the trade wind finally setting in, it fixed itself between 30,20 and 30,30, as long as the wind preserved its true direction.

4th. The month of September, 1802, and the greater part of August and October, we spent upon the east coast between the latitudes 23° and 17°. The south-east trade is the regular wind here, but we had many variations. Whilst the trade prevailed, the average standard of the mercury was 30,15, and the more southwardly it was, and the fresher it blew, the higher the quicksilver rose, though it never exceeded 30,30. When the trade wind was light, it was usual for a breeze to come off the land very early in the morning, and continue till eight or nine o'clock; but these temporary land winds did not produce any alteration in the mercury, which kept at these times about 30,10. When the trade wind veered round to ENE, or more northward, which was not seldom, the mercury ranged between 30 inches and 30,10; and when a breeze from north or N by W prevailed, which was the case for a considerable part of twenty days we remained in Broad Sound, its height was something, but not much, less. These northwardly winds I take to have been the north-east wind in the offing; which had been partly turned, and in part drawn out of its direction, by the peculiar formation of this part of the east coast. There are but few instances of any steady westwardly wind prevailing; when such happened, they were generally from the north side of west; and at these times the range of mercury was between 29,95 and 30,05, which was the lowest I at any time saw it on this portion of the east coast.

The barometer was of great service to me in the investigation of this dangerous part of the east coast, where the ship was commonly surrounded with rocks, shoals, islands, or coral reefs. Near the main land, if the sea breeze was dying

off at night, and the mercury descending, I made no scruple of anchoring near the shore; knowing that it would either be a calm, or a wind would come off the land; but if the mercury kept up, I stretched off, in the expectation that it would freshen up again in a few hours. Amongst the barrier reefs, when the wind was dying away, the barometer told me, almost certainly, from what quarter it would next spring up. If the mercury stood at 30,15, or near it and was rising, I expected the proper trade wind; and if higher, that it would be well from the southward, or would blow fresh; and if it was up to 30,30, both. The falling of the mercury to 30,10 was an indication of a breeze from the north-eastward; and its descent below 30 inches that it would spring up, or shift round to the westward. This regularity of connection between the barometer and the direction of the wind, is perhaps too great to be expected at a different time of the year; and it is probable, that we should not have found it continue so strictly, had our stay amongst the barrier reefs been much prolonged.

5th. Leaving the east coast in the latitude 17° south, we steered off to the northward for Torres' Strait, in the latter part of October. As we advanced northward, I found the mercury stand gradually lower with the same kind of wind and weather. The difference was not material till we reached the latitude 13°, but afterwards, the south-east wind which had before kept the mercury up to 30,15, then permitted it to fall to 29,90; and the winds from ENE and NNE to 29,85. Was this alteration owing to the want of density in the air brought in by the south-east winds, in this lower latitude?—to our increased distance from the land?—or was it, that the

south-east wind was no longer obstructed by the coast, having a passage there through Torres' Strait?

The difference between the height of the mercury, during a north-east and a south-east wind, was much less here than before, although the weather was most unfavourable during the time of the north-east wind, and should have increased the difference in their effects. Was this owing to the general approximation to that equality which has been observed to take place in the barometer, in very low latitudes?—or that the north-east wind, still meeting with resistance from the coast, had one cause for keeping up its power, which the south-east wind had lost?

In a general summary of the winds on the east coast, those that came from between south and east caused the mercury to rise and stand highest, as they had also done upon the south-coast, with the exception of the 4th example. The winds from NE kept the mercury up above 30 inches on the east coast, and caused it to rise after all other winds except those from the south-eastward; but on the south coast, the mercury fell with them, and stood considerably below 30 inches; because, as it appears to me, they then came from off the land. During north-west winds, the mercury stood lower than at any other time upon both coasts; and on both they came from off the land.

Moderate winds from the south-westward, with fine weather, caused a descent of the mercury on the east coast; and during their continuance it was much lower than with winds from the north-eastward; but upon the south coast it rose with south-west winds, and stood much higher than when they came from the opposite quarter. For this change I cannot

see any other reason, than that the wind, which blew from the sea upon one coast, came from off the land in the other.

Although the height of the mercury upon the south coast of Australia was, upon the average, considerably above the medium standard 29,50, it was still greater upon the east coast: I cannot fix it at less than 30,08 or 30,10, whereas upon the south coast, I should take it at 30 inches; both subject to the probable error of one or two-tenths of an inch in excess. This superiority seems attributable to the greater prevalence of sea winds upon the east coast, and particularly of those from SE, which, *when all other circumstances are equal*, I have observed to raise the mercury higher than any other on this side of the equator, analogous to the effect of north-east winds in the northern hemisphere; and perhaps also, the superiority may be in part owing to the east coast having a more regular chain of higher mountains running at the back of, and parallel to it, which presents a greater obstruction to the passage of the wind over the land, than it meets on the south coast.

The greatest range of the mercury observed upon the east coast, was from 29,60 to 30,36 at Port Jackson; and within the tropic from 29,88 to 30,30; whilst upon the south coast, the range was from 29,42 to 30,51, in the western part, where the latitude very little exceeds that of Port Jackson. It is to be observed, however, that these extremes are taken for very short intervals of time.

My observations upon the north coast of Australia are but little satisfactory, both because the changes in the barometer were very small in so low a latitude, and that very little more than the shores of the gulph of Carpentaria could be examined,

on account of the decayed state of the Investigator, which obliged me to return with all practicable expedition to Port Jackson. An abridged statement, however, of the general height of the mercury under the five following circumstances, will afford some light upon the subject, and perhaps not be uninteresting. 1st. On the east side of the gulph, and at the head, with the south-east monsoon, or trade wind. 2d. At the head of the gulph with the north-west monsoon. 3d. On the west side during the north-west monsoon. 4th. At Cape Arnhem under the same circumstance; and 5th. In the passage from Cape Arnhem, at a distance from the coast, to Timor, with variable winds.

In a memoir written by ALEXANDER DALRYMPLE, Esq. F. R. S. respecting the Investigator's voyage, there is this general remark:—"Within the tropics, the monsoon blowing "on the coast produces rainy weather, and when blowing "from over the land, it produces land and sea breezes." This I found verified on the east side of the gulph of Carpentaria, between Nov. 3 and 16, which time was employed in its examination; for though we had found the south-east trade to blow constantly on the east side of Cape York just before, and doubtless it did so then, yet in the gulph we had a tolerably regular sea breeze, which set in from the westward at eleven or twelve o'clock, and continued till seven, eight, or nine in the evening. Towards the head of the gulph, the trade wind, which blew at night and in the morning, came more from the NE, and the sea breezes more from north and NW, but without producing any regular alteration in the height of the mercury, whose average standard was 29,95: it never fell below 29,90 or rose above 30,04. At the head,

the height of the mercury remained nearly the same, until the north-west monsoon began to blow steadily, about the 10th of December, two or three days excepted, when the day winds were from the south-eastward, and the mercury then stood between 29,80 and 29,85. At these times, however, there was usually some thunder and lightning about, signs of the approaching rainy monsoon, which may perhaps account for the descent of the mercury independently of the direction of the wind.

2d. On the confirmation of the north-west monsoon, there was a change in the barometer at the head of the gulph, the common standard of the mercury being at 29,88; but during the times of heavy rain, with thunder, lightning, and squalls of wind, when amongst the islands of Cape Vanderlin, the mean height was 29,79. The north-west monsoon, after coming over Arnhem's land, blows along the shore for a considerable part of the space between the Cape Maria and Cape Van Diemen, of Tasman; and during the examination of the parts so circumstanced, we sometimes had tolerably fine weather, and the mercury above 29,90; but the wind was then usually more from the north than when the mercury stood lower. As we approached Cape Maria, and the bight between it and the south side of Groote Eyland, the mercury stood gradually lower; and in the bight, where the north-west monsoon came directly from off the shore, although we had sea and land breezes, with fine weather, according to Mr. DALRYMPLE'S general position, yet the mercury was uncommonly low, its range being from 29,63 to 29,81: the average 29,74, below what it had stood in the very bad weather near Cape Vanderlin. These winds and weather, and

the low state of the mercury, continued until we got without side of Groote Eyland.

3d. On the east side of Groote Eyland, and the west side of the gulph, northward from that island, we sometimes had sea and land breezes with fine weather; we had also two moderate gales of wind from the eastward, of from two to four days continuance each, with one of which there were heavy squalls of wind and rain; sometimes also, the winds were tolerably steady between north and west, with fine weather. During all these variations, the mercury never differed much from its average standard 29,90; and it seemed as if the increase of density in the air, from the wind blowing upon the coast, was equal to its diminution of quantity from the fall of rain and strength of the wind; and on the other side, that the wind from over that corner of Arnhem's Land permitted the mercury to descend, as much as the fine weather would otherwise have occasioned it to rise.

Upon the north side of Groote Eyland, the mercury stood higher than usual for five days, and during this time the wind blew with more regularity from NW, the only exception being for a few hours in the afternoons, when it commonly sprung up from the NE in the manner of a sea breeze: the weather remained fine during these five days, and the height of the mercury averaged 29,94.

4th. In the neighbourhood of Cape Arnhem, the mercury usually stood about 29,90, whether the wind was from NW, NE, or east, if the weather was fine; but if by chance the wind shifted to the south side of west, off the land, it descended to 29,80 though the weather remained the same: and this was its standard during those times when strong gusts

came from the NW accompanied with heavy rain, thunder, and lightning.

In this example, the wind from SW occasioned the mercury to stand lower than that from NW in the same weather; which is contrary to what was observed upon the south and east coasts; particularly on the former, where the south-west wind elevated the mercury up to, and sometimes above, 30,25.

5th. On March 6, 1803, we made sail off from the north coast, towards Timor, the north-west monsoon having ceased to blow at Cape Arnhem, and the eastwardly winds appearing to have set in; but we soon outran them, and had the wind so variable and light afterwards, that it took us twenty-three days to reach Coepang Bay, a distance of no more than 12° of longitude. The only two remarks I made upon the barometer during this passage were, that the common height of the mercury was 29,95 at those times that the wind remained steady for some hours, from whatever quarter it came, and about 29,85 when it was most unsettled; and that it stood higher, upon the average, after we had passed Cape Van Diemen, when the south-west winds, which blew oftenest, came from the sea, than it did before.

The medium height of the mercury, deducting the time between Cape Maria and Groote Eyland in the 2d example, I should take at 29,92, which, when the quantity of rainy squally weather, with thunder and lightning, is considered, is very high: the whole range of the mercury upon the north coast was four-tenths of an inch.

The principal differences in the effect of winds upon this coast, from what they produced upon the south and east coasts, are, that a north-east wind raised the mercury as

high, if not higher, than one from the SE; and that a north-west wind, where it came from off the sea and was moderate, was equal to either of them, and kept it up higher than the south-west wind did.

In order to have ascertained the full effects of sea and land winds upon the barometer, it was desirable to have learned, whether the south-east winds, which occasioned the mercury to rise highest upon the south and east coasts, would have left it at the medium standard, or made it descend upon the north-west and west coasts of Australia; but, unfortunately, the state of the ship did not permit me to determine this; for at the distance we kept from these coasts, in making the best of our way to Port Jackson, the accumulation of air over the shore, arising from a sea wind, or the contrary from a land wind, can scarcely be supposed to have much, if any effect. The principal winds we experienced between Timor and Cape Leuwen, in the months of April and May, were from SE and SW. The south-east wind prevailed as far as the latitude 25°, and the mercury stood at first with it at 29,95; but as we advanced southward, it rose gradually to 30,25, nearly in the same way as it had before descended on the east side of Australia, when we steered northward in the month of October. This wind was succeeded by an unsteady northwardly wind, which brought the mercury down to 29,90; but on its veering by the west to SW it rose fast, and fixed itself about 30,32: we were then drawing near Cape Leuwen.

As far as this example can be admitted in proof, it appears, that a wind from the SW has an equal, if not a superior power to one at SE in raising the mercury upon the west coast; which was not the case upon the south, and still much less

upon the east and north coasts, where the south-west wind caused it to fall. Winds from the northward caused the mercury to descend, as I believe they always will in the southern hemisphere, if not obstructed by the land; but upon the north coast, we have seen the mercury stand higher with it than almost any other.

Upon a summary of the effects of the same winds upon the different coasts of Australia, as deduced from the above examples, the following queries seem to present themselves.

Why do the winds from north and NW, which cause the mercury to descend and stand lower than any other upon the south and east coasts, as also in the open sea, and in the south-west bight of the gulph of Carpentaria, make it rise upon the outer part of the north coast, with the same, or even worse weather?

Why should the north-east wind, which occasions a fall in the barometer upon the south coast, considerably below the mean standard, be attended with a rise above the mean upon the east and north coasts?

The south-east wind, upon the south and east coasts, caused the mercury to rise higher than any other; why should it not have the same effect upon the north coast, and upon the west?

How is it that the south-west wind should make the quicksilver rise and stand high upon the south and west coasts,—should cause it to fall much below the mean standard upon the east coast,—and upon the north, make it descend lower than any other, with the same weather?

The answer, I think, can only be one; and it seems to be sufficiently obvious.

The cause of the sensibility of the mercury to winds blowing from the sea and from off the land, may perhaps admit of more than one explanation; but the following seems to me to be direct, and tolerably satisfactory. The lower air, when brought in by a wind from the sea, meets with resistance in passing over the land; and to overcome this resistance, it is obliged to rise, and will make itself room by forcing the superincumbent air upwards. The first body of air, that thus comes in from the sea, being itself obstructed in its velocity, will obstruct the second, which will therefore rise over the first in like manner, to overcome the obstruction; and as the course of the second body of air will be more direct towards the top of the highest part of the land it has to surmount, than the first was, so the first part of the second body will arrive at the top, before the latter part of the first body has reached it; and this latter part will not be able to pass over the top, being kept down by the second body and the successive stream of air, whose velocity is superior to it. In this manner, an eddy, or body of compressed, and comparatively inactive air will be formed, which, at first, will occupy all the space below a line drawn from the shore to the top of the highest land; but, almost immediately, the succeeding bodies of air, at a distance from the shore, will feel the effect of the obstruction; and being impelled by those that follow them, will begin to rise, taking their course for the top of the highest land, before they come to the shore; by which means, the stratum of lower air will be deeper between the top of the land and the shore, and to some distance out from it, than it is either upon the mountains or in the open sea. If this is admitted to be a necessary consequence of a wind blowing

upon the shore from the sea, it follows, that the mercury ought to stand something higher when such a wind blows, whether it is from the south or any other quarter, than it will with the same wind where it meets no such obstruction; and the more direct it blows upon the coast, and the higher the land is, (all other circumstances being equal,) the higher ought the mercury to rise. On the other hand, when the wind comes from off the hills, this dead and dense air will be displaced, even from its hollows under the highest land; both on account of its own expansion, and because its particles will be attracted by those of the air immediately above, which are taking their unobstructed course out to sea; and thus the air over the coast will resume its natural state with a land wind.

In order to appreciate duly the effect of sea and land winds upon the barometer, in the preceding examples, it is necessary to be recollected, that in the southern hemisphere, a wind from the south has a natural tendency to raise the mercury in the open sea, and one from the north to depress it; probably, from the superior density of the air brought in by the former; therefore, if the mercury rises quicker and higher with a south wind upon the south coast, than it does with a north wind upon the north, it is not to be at once concluded, that the effect of the wind as coming from the sea, is less upon the north coast; for it has, in the first place, to counteract the tendency of the mercury to fall with a north wind; and in some cases, its effects as a sea wind may be as considerable, relatively to the latitude, where there shall be no rise in the barometer, as upon the south coast it might where a considerable one took place. The same thing may be said

of the winds from the east and from the west; for where the vicinity of land is out of the question, the former generally causes an ascent, (from what principle I leave others to determine,) and the latter a descent in the barometer, and I believe this extends to both hemispheres, and all climates. The wind from SE then, which combines something more than half the power, both of the south and of the east wind, will raise the mercury higher than any other, on the south side of the equator, and the wind from NW permit it to fall lower, independently of their effects as sea and land winds; and this allowance requires to be first made upon them: the south-west and north-east quarters should be equal where there is no land in question, and of a medium strength between the power of the south-east, and the deficiency of the north-west wind.

I leave it wholly undetermined, whether the effects of sea and land winds upon the barometer, as above described, extend beyond the shores of the country where these observations were made, and to about one hundred leagues of distance from them; but it seems not improbable, that they may be found to take place near the shores of all countries similarly circumstanced; that is, upon those which are wholly, or for the most part, surrounded by the sea, and situated within the fortieth degree of latitude. In colder climates, where snow lies upon the ground during a part of the year, the wind from off the land may perhaps be so cold, and the air so much condensed, as to produce a contrary effect; but this, and the prosecution of the subject to other important consequences, I leave to the philosopher; my aim being only to supply my

small contribution of raw materials to the hands of the manufacturer, happy if he can make them subservient to the promotion of meteorological science.

I will conclude with stating a few general remarks upon the barometer, such as may be useful to seamen.

It is not so much the absolute, as the relative height of the mercury, and its state of rising and falling, that is to be attended to in forming a judgment of the weather that will succeed; for it appears to stand at different heights, with the same wind and weather, in different latitudes.

In the open sea, it seems to be the changes in the weather, and in the strength of the wind, that principally affect the barometer; but near the shore, a change in the direction of the wind seems to affect it full as much, or more, than either of those causes taken singly.

It is upon the south and east coasts of any country in the southern, or the north and east coasts in the northern hemisphere, where the effect of sea and land winds upon the barometer is likely to be the most conspicuous.

In the open sea, the mercury seems to stand higher in a steady breeze of several days continuance, from whatever quarter it comes, provided it does not blow hard, than when the wind is variable from one part of the compass to another; and perhaps it is on this account, as well as from the direction of the wind, that the mercury stands higher within the tropics, than, upon the average, it appears to do in those parallels where the winds are variable and occasionally blow with violence.

The barometer seems capable of affording so much assis-

tance to the commander of a ship, in warning him of the approach and termination of bad weather, and of changes in the direction of the wind, even in the present state of meteorological knowledge, that no officer in a long voyage should be without one. Some experience is required to understand its language, and it will always be necessary to compare the state of the mercury with the appearance of the weather, before its prognostications will commonly be understood; for a rise may foretel an abatement of wind,—a change in its direction,—or the return of fine weather; or if the wind is light and variable, it may foretel its increase to a steady breeze, especially if there is any easting in it; and a fall may prognosticate a strong breeze or gale, a change of wind, the approach of rain, or the dying away of a steady breeze. Most seamen are tolerably good judges of the appearance of the weather; and this judgment, assisted by observation upon the quick or slower rising or falling of the mercury, and upon its relative height, will in most cases enable them to fix upon which of these changes are about to take place, and to what extent, where there is only one; but a combination of changes will be found more difficult, especially where the effect of one upon the barometer is counteracted by the other; as for instance, the alteration of a moderate breeze from the westward with dull, or rainy weather, to a fresh breeze from the eastward with fine weather, may not cause any alteration in the height of the mercury; though I think there would usually be some rise in this case. Many combinations of changes might be mentioned, in which no alteration in the barometer would be expected, as a little consideration, or

experience in the use of this instrument, will make sufficiently evident; the barometer alone, therefore, is not sufficient; but in assisting the judgment of the seaman, is capable of rendering very important services to navigation.