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P. M. van Riel. The accuracy of barometer readings on board of moving ships.

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P. M. VAN RIEL. — THE ACCURACY OF BAROMETER READINGS ON BOARD OF MOVING SHIPS. — — — — — —

The future development of air traffic demands for more certainty in weather forecasts on shore and means for extending forecasts to oceanic areas.

In order to arrive at both purposes for N.W. Europe and the North Atlantic Ocean, it will be necessary to obtain sufficiently accurate observations, made on board of ships, on their journeys between Europe and America.

Since a good many years wireless meteorological reports from ships are being received by the Meteorological Office in London, but for various reasons the number of observations arriving in time for forecasting was unsufficient.

This year the M. O. is going to make an experiment on a larger scale; the number of ships, cooperating, will be such, that, on the mean, observations from 5 ships will be received four times daily. The observations will comprise pressure, wind, temperature, visibility, clouds etc.

The Norwegian Meteorological Office receives observations from 17 ships in the North Sea and Atlantic Ocean [1]).

Undoubtedly the most important of these observations are the barometer readings, which must give us a true idea of the distribution of pressure. The instruments in use on board merchant vessels are the mercury and aneroid barometer, and sometimes also a barograph for obtaining a continuous record of barometric pressure.

The aneroid barometer is liable to alterations in index error and scale value, making constant checking necessary; moreover it is often slow in following the changes in pressure, just like the barograph.

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1) Our own Institute receives twice daily wireless messages from two lightships in the North Sea.

The mercury barometer certainly gives more certainty at stations on shore, but on board the accuracy is diminished by the difficulty of obtaining true readings, when the barometer is „pumping." Ships mercury barometers therefore have to be tested as to their liability to show „pumping", which is diminished by narrowing the lower part of the barometer tube.

At first we intended to make an inquiry about the accuracy of barometer readings by comparing the observations of two ships (passing each other at some distance) both for mercury and aneroid barometers. By averaging the differences, evidence might be obtained about the fitness of both instruments for the use on board under all weather conditions.

However, as our Institute has put no confidence in aneroid readings since a long series of years and has provided the ships, which cooperate in taking observations, as much as possible with mercury barometers, the aneroid readings were too scanty to attach much importance to the results of the inquiry; therefore we restricted this investigation to a determination of the accuracy of the mercury barometer readings with increasing degrees of sea disturbance [1]).

The observations were taken from the logs of Dutch steamers, which in the last 30 years passed each other at a distance not exceeding 38 sm., between the 7th and 17th meredian of W. L. and at a latitude of about 49° N., during the months March, April and May.

The instruments in use were Marine Barometers, on the Kew principle, suspended in gimbals; the bore of the glass tube being constricted for the above mentioned reason. The time required for the mercury to fall from 25 mm. to 5 mm. above the existing pressure after being first set up, lies within the limits of 9 and 2 minutes. (Coefficient for sluggishness.)

The differences between the readings on both ships were corrected

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1) It would be interesting, if the same inquiry for aneroid barometers were made in another country. Comparison of mercury and aneroid barometer readings gave for eleven cases an average difference of 7.5 mm. However it must be stated, that in most cases the index error of the aneroid was not given and perhaps not known, importance being attached only to the *changes* in pressure.

for the distance by assuming a pressure gradient in harmony with the force of the wind and taking into account the angle between the direction of the gradient and the bearing between both ships.

In order to form an idea about the effect of this general way of correcting and about its accuracy, in view of the greatest distance admitted, the differences were classified according to the distances in 56 cases. The average differences are given in Table I in mm., those without correction for the distance in Table II.

Table I.

Distance in Seamiles.	0—9.9	10—19.9	20—29.9	30—39.9
Average Difference	0.39	0.66	0.74	0.87

Table II.

Distance in Seamiles.	0—9.9	10—19.9	20—29.9	30—39 9
Average Difference	0.41	0.83	0.80	1.09

Both tables show an increase of the average difference with the distance, but when the correction is applied this increase is much more regular, and the average difference is smaller. The results also show the necessity of not using great mutual distances, so that cases of distances greater than 22 sm. were left out. To the remaining 32 cases others were added unto a total of 95. From these 95 cases only 4 had to be discarded owing to the great difference between the observations, evidently due to errors in the reading or correction and not to „pumping".

The differences are given in Tables III en IV; a comparison of the results of both tables shows the value of the correction even for these small distances in causing a decrease of the differences; we have to pay attention further only to Table IV.

The classification took place according to the force of the wind, data about sea disturbance being less accurate. That only a few cases of forces, exceeding 7, should be at our disposal, might have been expected, as the average force is equal to the mean force 4.2; calcu-

Table III.

Force of the wind.	Differences of Barometer Readings in mm. (*not corrected* for distance.)							
	1—1.9	2—2.9	3—3.9	4—4.9	5—5.9	6—6.9	7—7.9	8—8.9
	0.6	0.3	1.2	0.9	0.6	1.0	1.2	0.6
	0.0	0.4	0.8	0.5	1.1	0.4		
	0.3	0.2	0.8	1.3	0.1	1.0		
	0.9	0.3	0.5	1.3	1.1	0.2		
	0.1	0.7	0.1	0.0	1.0	1.4		
	0.8	0.1	1.3	0.1	0.6	0.0		
	1.6	0.4	1.2	1.0	0.1	0.4		
		1.4	0.7	0.1	0.6	0.8		
		0.9	0.6	0.8	0.6	0.6		
		0.3	0.3	0.8	1.6	1.3		
		0.0	1.1	0.2	1.3	0.2		
		1.5	1.2	0.2	0.2	1.2		
		0.1	1.4	0.2	1.1	0.0		
			1.3	0.3	0.0	0.8		
			0.3	1.0	0.9			
			1.0	0.9	0.2			
			0.3		0.4			
			0.2		0.3			
			0.1					
			1.4					
			0.3					
Total	4.3	6.6	16.1	9.6	11.8	9.3	1.2	0.6
Number. . .	7	13	21	16	18	14	1	1
Average Difference. .	0.61	0.51	0.77	0.60	0.66	0.66		
Average Difference for all cases = 0.65 mm.								

Table IV.

Force of the wind.	Differences of Barometer Readings in mm. (*corrected* for distance.)							
	1—1.9	2—2.9	3—3.9	4—4.9	5—5.9	6—6.9	7—7.9	8—8.9
	0.6	0.5	1.1	0.8	0.2	0.8	0.0	0.2
	0.0	0.3	0.3	0.3	1.0	0.4		
	0.3	0.1	0.5	0.9	0.1	1.0		
	0.9	0.1	0.2	0.9	1.2	0.2		
	0.1	0.5	0.3	0.0	0.5	1.9		
	0.6	0.2	1.5	0.3	0.5	0.3		
	1.6	0.4	0.9	1.5	0.1	0.2		
		1.5	1.0	0.0	0.6	0.5		
		0.7	0.2	0.6	0.8	0.7		
		0.0	0.1	0.8	0.9	0.2		
		0.2	1.5	0.1	1.3	0.2		
		1.3	0.9	0.4	0.2	0.3		
		0.0	1.4	0.2	1.1	0.4		
			0.8	0.6	0.1	1.0		
			0.0	0.8	1.4			
			1.2	0.6	0.2			
			0.3		0.0			
			0.1		0.3			
			0.1					
			1.3					
			0.0					
Total	4.1	5.8	13.7	8.8	10.5	8.1	0.0	0.2
Number. . .	7	13	21	16	18	14	1	1
Average Difference. .	0.59	0.45	0.65	0.55	0.58	0.58		
Average Difference for all cases = 0.56 mm.								

lated out of fully 15000 observations in this part of the Ocean and for the above mentioned months [1]).

In 51 %, 28 %, 14% and 7 % of the 91 cases the differences were respectively less than 0.5, between 0.5 and 1.0, between 1.0 and 1.5 and between 1.5 and 2.0 mm.; the total average is 0.56 mm. *An increase of the differences with forces increasing from 1 to 7 is certainly not evident.*

From this fact we may conclude, that the differences are not due to „pumping" but to difference in sluggishness of the barometer, the location of the instrument at different places, unsufficient knowledge of the real temperature of the mercury, imperfect correction for the distance between both ships, difference in ships time, unsufficient checking of the index error, inaccurate reading, etc. The influence of the last three causes will be lessened, when ships-officers understand better the value of their observations for navigation and science. Then the inaccuracy will not be more than a few tenths of a mm.

Of course it will give some trouble to get a good reading in strong gales, especially on board of small ships, as in many of the above mentioned cases, but by taking the average of some highest and lowest readings, the error will be small and the reading will be sufficiently accurate for the construction of a weather chart.

In tropical areas of the Oceans, where the pressure is less liable to disturbances and corrections for the distance between both ships and changes in temperature are small, the result must be better. An inquiry made for these areas, some years ago, gave an average difference of about 0.34 mm. in barometer readings of two passing vessels.

As a curiosity we mention the fact, that the average difference between the readings at night proved to be smaller (0.43 mm.) than in the day time (0.64 mm.). The smallest average difference occurs at 4 a. m. (0.38 mm.).

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1) In the extraordinarily severe storm of January 9, 1913, two Dutch steamers passed each other at a distance of 6 sm. The difference between the mercury barometer readings was 0.6 mm.; force of the wind 12.