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Preface to the translation of "Die Sturmflut vom 12./13. November 1872 an den Ostseeküsten des Preußischen Staates" (Mit Zeichnungen auf Blatt F bis P im Text) by Otto Baensch (* June 6th, 1825 in Zeitz; † April 7th, 1898 in Berlin)

The original article „Die Sturmflut 12./13. November 1872 an den Ostseeküsten des Preußischen Staates (Mit Zeichnungen auf Blatt F bis P im Text)" was published in German by Otto Baensch (actually Otto von Baensch) in the "Zeitschrift für Bauwesen" 1875 by Ernst & Kern in Berlin. This article is one of the most valuable and comprehensive publications on the catastrophic storm surge of November 1872, and the English translation is intended to make this authentic historical document of the time available to an international audience.

The extensive meteorological and hydrological data on the 1872 storm surge collected by Baensch with great quality have been incorporated in numerous publications that were published afterwards. E. g. the impressive work of Colding (1881), also presented in its English translation in this issue of "Die Küste", is based on the collection of Baensch reliable data. Colding's paper derives its importance from the physical theories. Therefore, he used all available data on the storm surge of 1872, especially those collected by Baensch, to modify his ideas on sea level response to wind. Based on his analysis of air pressure and the derived wind field data from Baensch, Colding was able to make an important contribution to the still lasting controversy about the cause of the extreme water levels during the storm surge of 1872. Recent publications on historical storm surges in the Baltic Sea, such as Jensen et al. (2022), also printed in this issue of Die Küste, also refer to Baensch's high-quality and very well-researched data.

The translation into English was prepared by Mrs. Michaela Stiller and produced by me with the support of Simon Beckmann, Christoph Blasi, Dr. Jacobus Hofstede, Rena Jensen and Dr. Gudrun Rosenhagen. The authentic character of this contemporary document should be preserved as much as possible, therefore the original drawings were not translated. I would like to sincerely thank all those involved for their support during the translation.

The following is to be noted regarding the remarkable career as an engineer and natural scientist of Otto Baensch (see Wikipedia, https://de.wikipedia.org/wiki/Otto_Baensch_(Ingenieur): Otto Baensch studied surveying and mathematics at the University of Halle from 1842 to 1847 and entered the Prussian civil service after attending the Berlin Bauakademie. In the early days, he was mainly engaged in the construction of churches in the province of Pomerania. After overseeing reconstruction work on Cammin Cathedral, he took charge of the new construction of Heringsdorf Church on Usedom in 1848. In 1855 he became a land architect in the administrative district of Legnica (Liegnitz). From 1858 he was construction manager of the Ruhr-Sieg Railway. Between 1852 and 1871, Otto Baensch was a hydraulic engineering inspector in Stralsund and Coeslin (Cöslin). During this time, he wrote, among other things, about harbour construction, lighthouses and dike construction.

After his transfer to the Prussian Ministry of Trade, Commerce and Public Works in Berlin, his tasks included the regulation of the Elbe and Rhine rivers, the canalization of the lower reaches of the Main River from Frankfurt to Mainz (1882 to 1885) and dike

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construction in the province of Schleswig-Holstein. From 1886, he led the construction of the Kaiser Wilhelm Canal (1887 to 1895), today's Kiel Canal.

Otto Baensch was an honorary citizen of the city of Zeitz and was awarded the honorary title of "Geheimer Oberbaurat". In 1895, Otto Baensch was awarded the personal title of nobility "Otto von Baensch" by the Kingdom of Bavaria, but he did not make use of it.

November 2022
Jürgen Jensen

The storm surge of November 12th–13th, 1872, on the Baltic coasts of Prussia

Baensch, Otto translated by Jürgen Jensen

Keywords

Baltic Sea, storm surges, damages, historical storm surges 1320, 1625 und 1872, water level, hydrotechnical and meteorological phenomena, historic units of measurement, Prussia

Schlagwörter

Ostsee, Sturmfluten, Schäden, historische Sturmfluten 1320, 1625 und 1872, Wasserstand, hydrotechnische und meteorologische Phänomene, historische Maßeinheiten, Preußen

Zusammenfassung

Der Originalartikel „Die Sturmflut vom 12./13. November 1872 an den Ostseeküsten des Preußischen Staates - Mit Zeichnungen auf Blatt F bis P im Text“ wurde von Otto Baensch (eigentlich Otto von Baensch) in der Zeitschrift für Bauwesen 1875 von Ernst & Kern in Berlin veröffentlicht (Baensch 1875). Diese Publikation ist einer der wertvollsten und umfassendsten Beiträge zur katastrophalen Sturmflut im November 1872. Die Sturmflut vom 12. und 13. November 1872 hat sich auf die damaligen preußischen Küsten der Ostsee verheerend ausgewirkt und war im Vergleich zu allen aus früherer Zeit bekannten Sturmflutereignissen hinsichtlich der Folgen so katastrophal, dass Baensch sehr weitsichtig eine detaillierte Untersuchung des Phänomens „Sturmflut“ in seinen Ursachen und Verlauf sowie eine Dokumentation der Folgen und Schäden für zwingend erforderlich hielt. Dazu wurden die damaligen Regierungen von Danzig, Cöslin, Stettin, Stralsund und Schleswig, sowie die Provinzen von Stade und Aurich aufgefordert, alle verfügbaren Daten und Beobachtungen sowie weitere Hinweise zu recherchieren und zu dokumentieren, um die meteorologischen und hydrologischen Prozesse der Sturmflut 1872 zu einem Gesamtbild zusammenzuführen. Die Daten wurden von Baensch in erstaunlicher Quantität und Qualität recherchiert und mit bis heute hervorragenden Grafiken aufbereitet. Diese Daten stellen bis heute die wertvollste Datengrundlage zur Sturmflut vom 12. und 13. November 1872 dar. Die Publikation von Baensch (1875) wird bis heute vor allem wegen der Sammlung einer großen Zahl zuverlässiger meteorologischer und hydrologischer Daten der Sturmflut 1872 geschätzt. So nutzte z. B. Colding (1881) die Daten von Baensch zur Sturmflut von 1872, um seine ozeanographischen und physikalischen Theorien über die Reaktion des Meeresspiegels auf Windeinwirkungen zu bestätigen und zu modifizieren.

Darüber hinaus hat Baensch auch die Wasserstände und Schäden der historischen Ostseesturmfluten von 1304, 1309, 1320, 1625, 1694 und 1784 aus Archiven und Chroniken mit erstaunlicher Qualität zusammengetragen. Diese historischen Daten werden bis heute verwendet.

Zu der bemerkenswerten Karriere als Ingenieur und Naturwissenschaftler von Otto Baensch (6. Juni 1825 in Zeitz; † 7. April 1898 in Berlin; vollständiger Name: Otto Friedrich Bernhard Baensch) ist Folgendes festzuhalten: Otto Baensch studierte von 1842 bis 1847 Vermessungstechnik und Mathematik an der Universität Halle und trat nach dem Besuch der Berliner Bauakademie in den preußischen Staatsdienst ein. Anfänglich war er vor allem mit dem Bau von Kirchen in der Provinz Pommern beschäftigt. Nachdem er Umbauarbeiten am Camminer Dom geleitet hatte, übernahm er die Leitung des Neubaus der*

Heringsdorfer Kirche (1848) auf Usedom. 1855 wurde er Landbaumeister im Regierungsbezirk Liegnitz. Ab 1858 war er Bauleiter der Ruhr-Sieg-Bahn. Zwischen 1852 und 1871 war Otto Baensch Wasserbauinspektor in Stralsund und Köslin. In dieser Zeit verfasste er u. a. Schriften über Hafenbau, Leuchtfeuer und Deichbau.
Nach seiner Versetzung in das preußische Ministerium für Handel, Gewerbe und öffentliche Arbeiten in Berlin gehörten die Regulierung von Elbe und Rhein, die Kanalisierung des Mainunterlaufes von Frankfurt bis Mainz (1882 bis 1885) und der Deichbau in der Provinz Schleswig-Holstein zu seinen Aufgaben. Ab 1886 leitete er den Bau des Kaiser-Wilhelm-Kanals (1887 bis 1895), des heutigen Nord-Ostsee-Kanals. Otto Baensch war Ehrenbürger der Stadt Zeitz und wurde mit dem Ehrentitel Geheimer Oberbaurat ausgezeichnet. Vom Königreich Bayern wurde Otto Baensch 1895 der persönliche Adelstitel „Otto von Baensch" verliehen, von dessen Verwendung er aber keinen Gebrauch machte.

1 The Storm Surge of November 12th–13th, 1872 on the Baltic Sea Coasts of the Prussian State

The storm of November 12th–13th, 1872, had such a devastating effect on the Prussian coastal districts of the Baltic Sea, and its occurrence was so serious in comparison with all those known from earlier times, that it certainly called for a detailed study of the entire phenomenon in its causes and course, as well as a clear demonstration of its consequences for the beach districts and the buildings located within them.

For this purpose, the governments of Gdansk (Danzig), Coeslin (Cöslin), Szczecin (Stettin), Stralsund and Schleswig, as well as the provincial authorities of Stade and Aurich were asked to collect the material available for this purpose, and the following discussion of the meteorological and hydro-technical phenomena combines this collected material into an overall picture of the whole phenomenon, using other auxiliary sources, which could be obtained from isolated brochures, from scattered notes or local observations.

From the observation material in meteorological relation, the details have been excluded as far as they would have complicated the discussion. Only that has been used which allows the phenomenon to be overlooked in the simplest possible reproduction. In order to make the tables of figures easier to understand, they have been presented graphically throughout.

2 Historical Storm Surges

Phenomena such as the storm surge of November 12th–13th, 1872 have been reported as far back as historical records go; but it is always the historian, not the technician, who passes on the bare facts in a few words to posterity.

The oldest storm tide, of which the chroniclers report, also only according to oral tradition, was at the beginning of the 14th century; according to Berckmann and Kantzow at Stralsund in the year 1304, according to another Stralsund chronicle in 1307, according to Micraelius in 1309 and according to the Lübeck chronicle in 1320.

Berckmann reports about this storm tide in the Stralsund chronicle:

„Im J. 1304 umme alles Gades hilligen (am 1. November) weyede so ein groth stormwind, nicht gehört bi minschen thiden, Böme uth de erden, Dörpe, möhlen umme un mackede so groth water umme dit land, datt dat nye - Deep uthbrack; um da de von Cickeren plegen eren weiten tho seyen up den Ruden und tho gande von einem lande up dat andere, dat wafs water,"

Or: In the year 1304 around All Saints' Day, a great storm wind, not heard in human times before, knocked down trees from the earth, villages and mills and drowned the land with so much water that the "Neue Tief" (New Deep, erosion channel and later fairway south of Mönchgut) broke out and that the people of Zicker (place on Mönchgut) who used to sow their wheat on Ruden (seems to be missing the conclusion: "could no longer get there") and the whole area between one land (Mönchgut) and the other (Ruden) was flooded with water.

About the same event, Thomas von Kautzow says: In the same year, there was an enormous storm. It tore off the land of Ruden from Rugen (Rügen), between which previously ran only a small river one could jump over.

The distance from Ruden to Rugen (Rügen) is today one German mile.

If we consider that the storm surge at that time tore Ruden away from the island of Rugen, forming the "Neue Tief", while the most recent storm surge submerged the whole of Ruden, except a few dune sections, and tore away large parts of the beach everywhere, we can conclude that the storm surge of November 12th–13th, 1872 is the most devastating in terms of its impact.

The next storm tide mentioned by chronicles after the one at the beginning of the 14th century was that of February 10th, 1625. Water level marks of it on the blue tower in Lübeck and on the old official building in Travemuende (Travemünde) have preserved a consistent reference for the assessment of the height of the tide. According to these marks, the water level reached an absolute height of 23' 9" = 7.454 meters (prussian foot ≙ 31.3854 cm, prussian inch ≙ 2,615 cm, 23' und 9" ≙ 7,454 meters), a height of 2.804 meters above mean sea level.

If we compare this level with that of the flood of November 12th–13th, 1872, which reached 3.380 metres above mean sea level, we find that the level of February 10th, 1625 is 0.576 metres lower; and nevertheless also the damage caused by this storm surge was very considerable, as the chronicler Becker at Lübeck and M. Johannem Stein, preacher at Rostock, tell.

It is worth mentioning at this point that according to Stein "on February 10th at noon, the water not only rose suddenly and unusually high, but also that soon afterwards a terrifying and unheard of impetuosity arose from a violent and strong northeasterly gale. It blew in such a way with incessant hissing and roaring, mixed with heavy snow and rain, that thereby not only at sea and at Warnemünde, but also here in Rostock great damage was done," etc.

The last storm tide to be mentioned here is the one of January 10th–11th, 1694, from which a water level mark has also been preserved at the blue tower in Lübeck, according to which this tide exceeds the one of 1625 by a small amount, namely by 0.019 metres. Accordingly, the flood of 1694 would be in line with that of 1872 in terms of height – as far as the water level marks show.

The later storm surges do not reach the two specifically mentioned ones of 1625 and 1694 (of the storm surge that took place in September of the year 1784 nothing exact can be stated, since no water level marks of the same have survived to our time), as the graphic representation of the highest and lowest water level of the Trave estuary, as a point strongly exposed for storm surges at the Baltic Sea coast in the later years, can be seen in Figure 1 of the drawings.

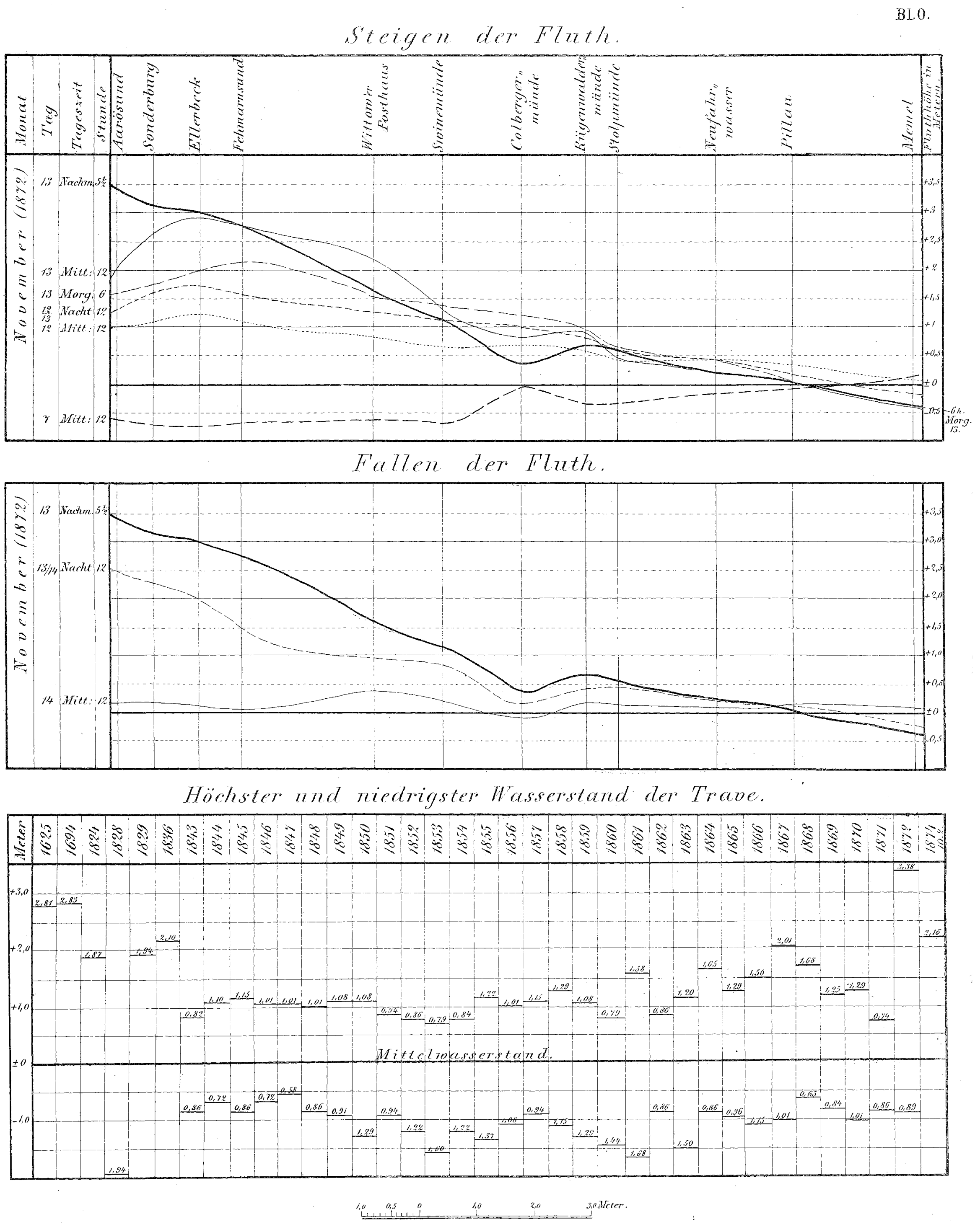

Figure 1: Rising Tide, Falling Tide, Highest and Lowest Water Level of the Trave.

It should not go unmentioned here that in more recent times similar phenomena have occurred more frequently, even if not as devastating in their effects.

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3 The Meteorological Phenomena before and during the Storm Surge

3.1 The Absolute Values of the Atmospheric Pressure and the Temperature together with the Wind Movement

In order to determine the origin of the storm from NE or ENE which caused the storm surge, as well as the reasons for the increased strength of the storm, which reached hurricane strength only on one part of the Baltic Sea coasts, it is necessary to get a picture of the atmospheric conditions over the area in question before and during the storm surge.

The area of observation including the Prussian coasts is far too limited for the evaluation of such movements of the atmosphere. Furthermore, from the stations outside Prussia, the data for the evaluation of the deviation of the condition from the mean values of the air with respect to pressure and temperature are lacking. Before examining the meteorological conditions on the Baltic coast in particular, an attempt has been made to draw a general picture of the conditions and changes in the atmosphere just before and during the storm surge over Northern and Central Europe, from Haparanda to Vienna and from Paris to Moscow. It is based on the observation results published daily in the "Staats-Anzeiger".

The observation material of the atmospheric pressure in the mornings of November 10th, 11th, 12th and 13th is compiled to graphical representations. They comprise four tables of the mentioned area of Europe and show in lines the position of the same barometer reading at intervals of 2.5 to 2.5 Paris lines in the morning of each observation day. Those lines will be called "equal pressure lines".

From the change of the phenomena represented by 24-hours observations, one is able to judge the variations of the atmosphere also for the intervening time.

These maps, Figure 2 and Figure 3, are drawn at a scale of 1:15,000,000 and show only the natural demarcation between land and water of Northern and Central Europe. Furthermore, the meteorological stations are indicated by small circles. Because of the small scale and space, the names of the individual stations are described in the map, Figure 3.

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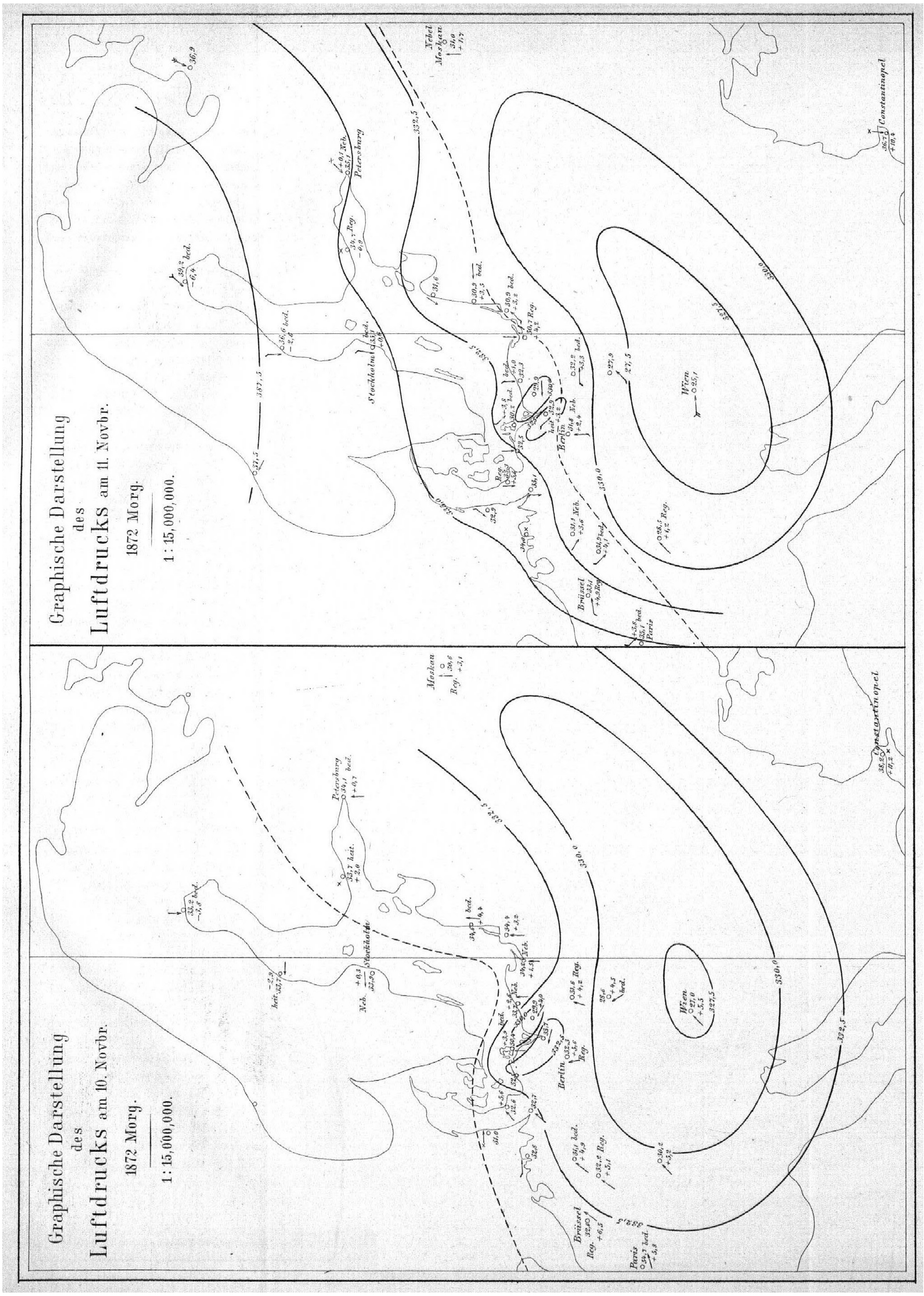

Figure 2: Weather Charts of November 10th–11th, 1872, in the Morning.

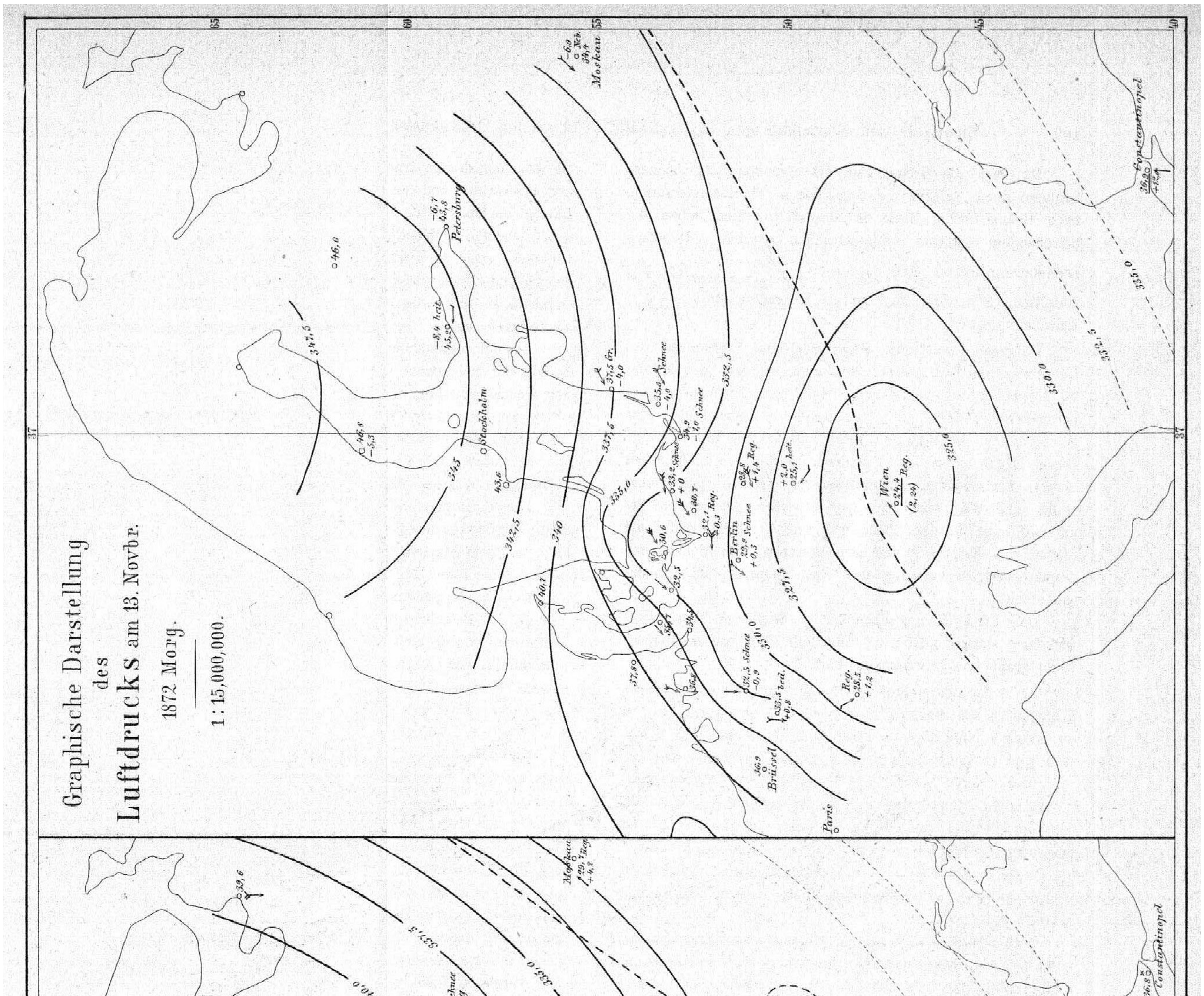

Figure 3: Weather Charts of November 12^{th}–13^{th}, 1872, in the Morning.

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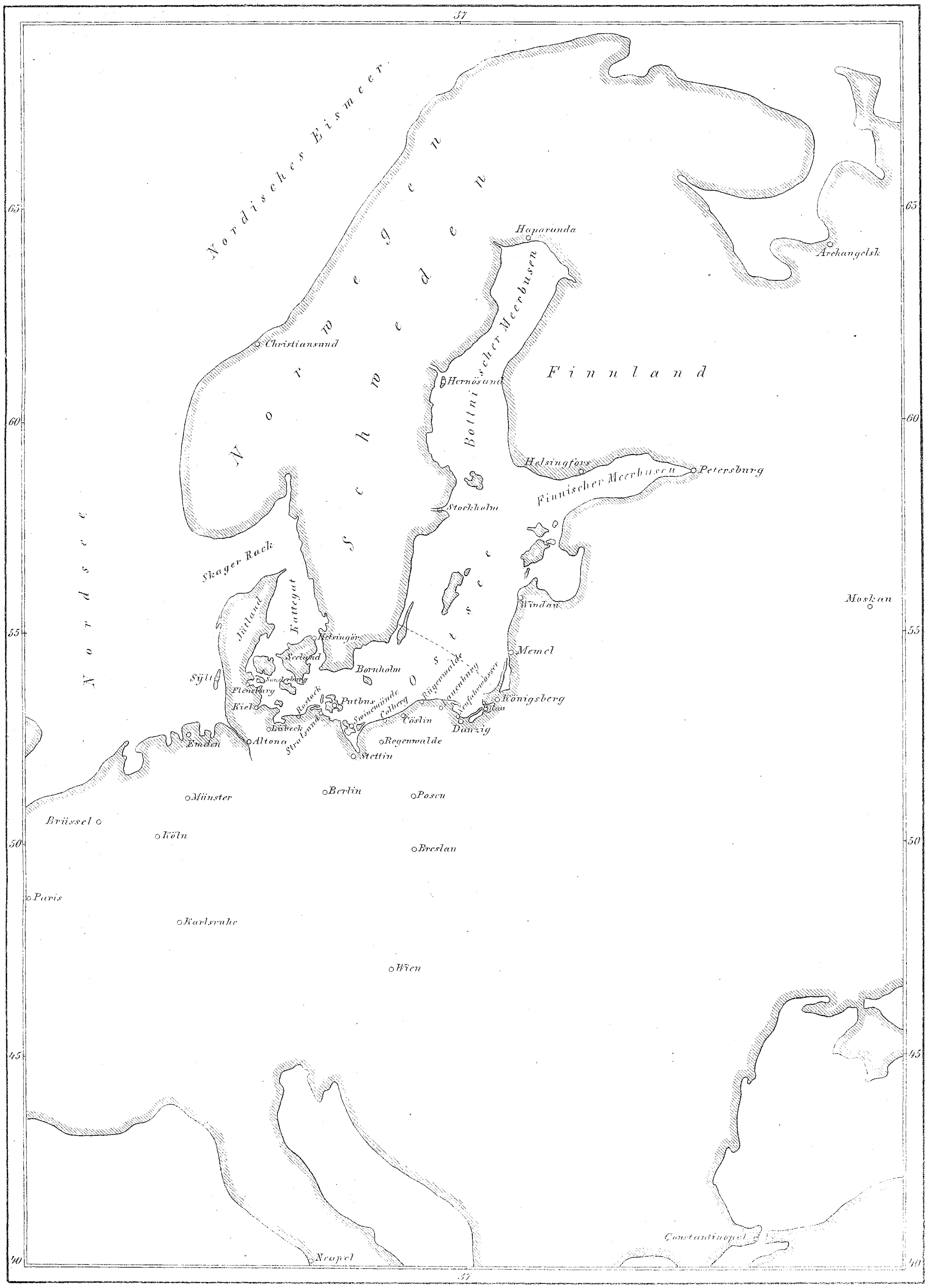


Figure 4: Map of the Meteorological Stations plotted in the Air Pressure Analysis of Figure 2 and Figure 3.

The barometer readings published in the above-mentioned daily weather bulletins and the readings reduced to 0 °R are shown numerically in Paris lines, precisely only the numbers above 300 lines.

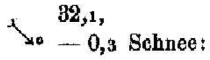
As the stations themselves are at different heights above sea level, the air pressure would also have had to be reduced to sea level. This was not done, because at a difference of 100 feet the deviation of the barometer reading is on the average only 1.033 Paris lines, i.e. less than the distances of the equal pressure lines from each other, which are wide in 2½ Paris lines, and therefore the characteristics of the lines can suffer a loss of accuracy which is not too significant. Another reason for this was that the altitude is only known for a small proportion of the weather stations. Only in one report, namely in the one by G. v. Boguslawski – as a supplement to the report of the government in Szczecin (Stettin) – were the altitude differences of individual observation sites mentioned in the table.

For the sake of completeness, it would be desirable that at least once a year the relevant information were given in connection with the daily weather report.

In order to be able to see the connection of the wind with the distribution of the atmospheric pressure on the graphic representations, the direction as well as the intensity of the wind are given, the former is indicated by small arrows, which adapt themselves to the orientation of the maps, the latter by small flags. In terms of intensity, the following degrees are established as the norm:

windstill	(calm),
windig	(breezy),
starker Wind	(strong wind),
Stürmisch	(stormy),
Sturm	(storm)
Orkan	(hurricane)

Since the temperature also serves as a basis for safe conclusions, the observed thermometer readings have been inscribed in absolute numbers next to the respective stations according to Réaumur's scale. Accordingly, for any station this means: stormy, barometer reading 32.1 Paris lines, −0.3 °R cold with snow.



Overlooking this graphical representation of the air pressure and the other phenomena of the morning of November 10th, we find that over Central Europe a barometric minimum, with its major axis over Vienna (Wien), extends in the direction from WSW to ENE. This minimum was the flood channel for the Equatorial Current that had prevailed since the beginning of the month, as evidenced by the reported wind and temperature observations. This is the normal situation for the Equatorial Current, and one of the reasons for the strength of the struggle between the Polar and Equatorial Currents, which, as is well known, is always repeated.

That this struggle already took place on November 10th in the beginning of its development is shown by a glance at the relevant graphical representation, see Figure 2 and Figure 3.

In Haparanda, on the morning of November 10th, a moderate wind blew directly from the north; in Memel, Petersburg and Moscow (Moskau) a moderate wind blew directly from the south. At Helsingfors (Helsinki) there was no wind, and at Stockholm and Härnösand there was a straight easterly wind.

This shows that between Haparanda and Härnösand the two currents were directly opposite each other and kept the balance, and that in Härnösand and Stockholm there was a flow of the accumulated air to the west. Finally, in Petersburg and further to the east, no trace of the influence of the Polar Current was recognized.

If one adds the temperature observations, according to which the thermometer showed −3.8 °R in Haparanda, -2.9 °R in Härnösand, on the other hand +0.3 °R in Stockholm, +2.0 °R in Helsingfors (Helsinki), +0.7 °R in Petersburg and +3.1 °R in Moscow (Moskau), so one finds – apart from the relatively small effects of the local position of the stations – not only the confirmation of the situation previously explained. Furthermore, if one now additionally considers the "General View of the Sky", which is reported from Haparanda as "overcast", from Härnösand as "clear", from Stockholm as "fog", from Helsingfors (Helsinki) as "clear", from Petersburg as "cloudy", the border between Polar and Equatorial Current, i.e. the zone in which the air masses of the two currents mix and are usually characterized by fog, can be approximately determined.

Therefore, one can conclude that in Härnösand only the air of the Polar Current, but in Stockholm the same air mixed with warm, light air of the Equatorial Current, had to flow westward into the oceanic basin.

The temperature in Helsingfors (Helsinki), which is +1.3 °R higher than in Petersburg, which is almost at the same latitude, can probably be explained by the stationary air of the Equatorial Current.

If one now goes further south to determine the boundary line between Equatorial and Polar Current, then one finds from Coeslin (Cöslin) to Memel the direction of the wind marked as Equatorial Current. As to the difference in temperature and the "General View of the Sky", Gdansk (Danzig) reports only +l.5 °R and "fog", Coeslin (Cöslin) +2.0 °R as well "fog", however, Koenigsberg (Königsberg) and Memel +3.8 °R or 4.4 °R; respectively i.e., in Gdansk (Danzig) and Coeslin (Cöslin) the warm moist air of the Equatorial Current was already mixed with the cold dry air of the Polar Current.

From the above follows that near Gdansk (Danzig) the Polar Current had already entered the Equatorial Current in a wedge shape on November 10th in the morning. Accordingly, the extrapolation of the discussed boundary has been drawn in the graphic representation as a broken line; the extrapolation of this line from Coeslin (Cöslin) to the west has been likewise determined according to this principle.

Comparing in both areas of the air currents the air pressure at Stockholm represented by the equal pressure lines with the maximum of 333.9", at Coeslin (Cöslin), immediately near or on the boundary of the two air current areas discussed above, with 333.7", it results in the area of the Polar Current a difference of 0.2" at a distance of 80 miles or 0.25" at 100 miles, whereas for the area of the Equatorial Current with the minimum in Vienna (Wien) of 327.0" - between Vienna (Wien) and Coeslin (Cöslin) there is a difference of 6.7" at a distance of 90 miles or 7.4" at 100 miles.

It can be seen from this that the pressure of the cold air accumulated in the north was almost in equilibrium, in contrast to the warm air of the Equatorial Current, which was moving along in rapidly decreasing pressure. If we consider this fact, particularly unfavourable at extremely low atmospheric pressure, in connection with the partial intrusion of the Polar Current into the Equatorial Current evident from the boundary line of the two air currents, the outcome of the struggle already in progress can generally be foreseen.

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If we now compare the graph of the air pressure on November 10th with that in the morning of November 11th, a significant change becomes apparent, especially in the area of the Polar Current. The Polar Current itself had gained significant terrain in the previous 24 hours, as shown by the borderline between the Polar and Equatorial Currents, marked in the graph for November 11th and drawn according to the same principle as before.

During this advance of the Polar Current, especially where the partial intrusion had occurred and where also on this day a further advance in the torn marked boundary line is evident, the air pressure has become lower, because the equal pressure line of 332.5" has advanced significantly from the minimum air pressure to the north beyond Riga. Both this fact and an absolute decrease of the minimum at Vienna by 1.9" are probably proofs that the Polar Current on the line mentioned above lifted the Equatorial Current so that the latter passed over the former while the cold air in the lower layers advanced. If the arithmetic sum of the air pressure from the lower cold current and the warm current flowing above has suffered a reduction, although cold heavy air has penetrated into these areas, then it can only be concluded that the upper warmer current has moved with greater force and that the resulting reduction of the air pressure has not yet been compensated by the heavier layers of the lower cold air. This phenomenon is all the more characteristic, however, because, contrary to the normal simultaneous movements of the thermometer and barometer, it also marks a simultaneous fall of the barometer with the falling thermometer and thus permits a conclusion as to the eminent force of the Equatorial Current in the upper layers.

On the other hand, we find that the air pressure in the southwestern direction from the island of Rugen (Rügen) has changed only insignificantly, e.g. for the equatorial pressure line 332.5 not causing any displacement, while between Moscow (Moskau) and Petersburg the same line has advanced south eastward from the maximum at Haparanda; a proof that the Equatorial Current at Moscow (Moskau) resisted - albeit relatively, and thus the air pressure has increased.

Comparing the differences in atmospheric pressure in the two areas against each other, between Haparanda and Gdansk (Danzig) – at a distance of about 185 miles – there is a difference of 8.5" or 4.6" at 100 miles; between Gdansk (Danzig) and Vienna (Wien) at a distance of 95 miles, there is a difference of 5.6" or 5.9" at 100 miles.

If one compares the differences in atmospheric pressure of the previous day of 0.25" and 7.4" with those of this day of 4.6" and 5.9", and takes into account that the air pressure on November 10th in the morning decreasing from Stockholm to the north still increased in Stockholm itself by l.2" with a difference of 4.1" to 125 miles to the north, we find confirmed that the air of the Polar Current region, which was still almost in equilibrium 24 hours before, advanced from the north to the south with rapidly increasing pressure. In doing so, it pushed back the Equatorial Current in its entire front, even lifted up the Equatorial Current in the extension discussed above, and thus penetrates wedge-shaped into the latter below.

With these phenomena of November 11th, an attentive observer would have foreseen the onset of a stronger current, since the struggle was already present in such pronounced symptom.

If the progress of the effects of the Polar Current from the morning of November 10th to the morning of November 11th was already a significant one, the graphic representation of the atmospheric pressure of the morning of November 12th shows the complete collapse of the Polar Current for the area in question. One station in the north, Moscow (Moskau), still gives us information about the presence of the descending Equatorial Current, by the direction of the wind and by the temperature.

While in Petersburg the temperature was −6.8 °R with northerly wind, in Moscow (Moskau) it was +4.2 °R with wind from SW; there is a colossal difference of 10.4 °R between the two places. Together with the rain reported from Moscow (Moskau), the convergence of the Equatorial Current and the Polar Current may be plotted into the graphic slightly to the northwest of Moscow (Moskau).

To determine approximately the whole convergence line, the observations of Vienna (Wien) remain. As the effects of the Polar Current - northwesterly wind with snow and a daily mean temperature of 2 °R only - are to be regarded as fixed, the boundary between the two air currents going east of Vienna (Wien) and west of Moscow (Moskau) has been drawn by approximation in a broken line into the map of November 12th.

Considering the change of the air pressure in the last 24 hours, or in other words, the shift of the equal pressure lines, more closely, it turns out that all stations which were in the area of the Polar Current on the morning of the November 12th show increased air pressure ore the equal pressure lines have shifted down from north to south, respectively; namely, since the morning of November 11th the increase in pressure in Haparanda amounts to 4.2'' and in Vienna (Wien) to 0.5''. This general increase in air pressure in the whole Polar Current region is not only the product of the still increasing pressure in the north, but also of the resistance, even if only relative, of the Equatorial Current. If we note the difference in air pressure on the morning of November 12th in the entire Polar Current region, we find that between Haparanda and Vienna (Wien), between maximum and minimum, at a distance of 275 miles, there is a difference of 17.8'', or of 6.5'' at 100 miles.

The change in atmospheric pressure in the equatorial region, on the other hand, results in a diminution of the same, namely at Moscow (Moskau) by 1.3''. This decrease in air pressure, together with the wind direction - SW in Moscow (Moskau) - confirms not only the Equatorial Current in Moscow (Moskau), but also shows that the Polar Current - between Petersburg and Moscow (Moskau) - moves besides the Equatorial Current approximately in parallel with the latter. This causes a decrease of normal attack and the increase of the air pressure resulting from it ceases.

The reports from several stations made on the morning of November 12th, namely in the Baltic Sea, of the increasing intensity of the Polar Current appearing as a strong and stormy wind from NNE and E, leave no doubt about the resulting consequences. The direction of the Polar Current was more and more directed from NE to SW and its course thus pointed to the western basin of the Baltic Sea.

On the morning of November 13th, when the raging storm had reached its climax at the Prussian coasts, the conditions of the atmospheric pressure had become quite different in the meantime. Unfortunately, due to the lack of observations from the meteorological stations, no graphic representation can be given of the atmospheric processes for the intervening period from the morning of November 12th to the morning of November 13th.

What is especially noticeable on the map of November 13th as to air pressure is the change in the boundary between the Polar and Equatorial Currents, in favour of the latter. This boundary line has made a turn from the direction SSW/NNE to SW/NE in such a way that Vienna (Wien) has again entered the area of the Equatorial Current, while Moscow (Moskau) has now entered the area of the Polar Current.

In Vienna (Wien), there is rain and the daily mean temperature increased by 0.24 °R with wind from SW, in Moscow (Moskau), however, there is fog at a temperature of −6.0 °R and strong wind from NE. Both tracks took their natural direction, namely the Polar Current, by deflecting the Equatorial Current on November 12th at the level of Moscow (Moskau), prepared its parallelism with the latter, lost its normal position of the attack front and took its direction all in all more to the west. As a result, the southern Equatorial Current blowing at the height of Vienna (Wien) was more and more relieved from the attack of the Polar Current. With the intensity of the Equatorial Current, its return to its natural direction from SW to NE was facilitated by the deflection of the Polar Current. Only while at the beginning of November the Equatorial Current dominated the Baltic Sea area, it is pushed back on its whole path to the south and the Baltic Sea with the northern part of Germany taken as a flood bed by the Polar Current. The days from November 10th to 13th form the transition period from the first situation to the second.

If we now compare the conditions of the air pressure on the morning of November 13th with those on the morning of November 12th, we find that there was an increase in the pressure maximum near Härnösand of 3.1''. From there in a southeastern direction, corresponding to the change of the area of the Polar Current, there is a steady increase in air pressure up to beyond Moscow (Moskau) – in Moscow (Moskau) itself by 4.7''. In the southwestern direction from Härnösand to Rugen (Rügen), the pressure increase occurred only up to the equal pressure line 335.0'', but from there to the minimum near Vienna (Wien) there is a significant decrease in air pressure, especially in the equal pressure line 332.5''. The differences are 16.3'' at 130 miles or 12.5'' at 100 miles in the Härnösand-Putbus profile line on the morning of November 13th, and 8.4'' at 100 miles on the morning of November 12th.

The readings on the Putbus-Vienna (Wien) profile line on the morning of November 13th were 6.2'' at 95 miles or 6.5'' at 100 miles against 7.6'' at 100 miles on the morning of November 12th. These colossal differences had to be followed by phenomena of such eminent and disastrous force as from November 12th to 13th at night, because, while afterwards on the morning of November 12th the pressure between Härnösand and Vienna (Wien) decreased rather evenly; by the morning of November 13th the pressure in the northern region had increased enormously. This might be caused in part by the cold air advancing from the north, while at the same time the Equatorial Current resumed its old direction, and thus north of Vienna (Wien) again restricted the profile of the Polar Current.

Just this latter swing of the Equatorial Current in its natural direction shows that the initially normal attack of the Polar Current was defeated, which could have led to a complete breaking of the free flow and then would have resulted in a strong northwesterly and northerly storm at the coasts.

This breakthrough failed because of the strong resistance of the Equatorial Current. A lateral air movement was initiated in the north, directed more to the NE, which gave the Equatorial Current the strength to return to its natural direction from the SW, but with simultaneous restriction of the tidal profile of the Polar Current at the height of Rugen (Rügen), as a result of which the air was forced more to the NE, had to assume a high speed, and turned into the dangerous hurricane.

In the four graphs (Figure 2 and Figure 3), the position of the air movements on the four days of struggle will give an approximate overview of how the changes proceeded:

As the change in the direction of the Equatorial Current from November 12th to 13th already caused the high velocity of the air over the western basin of the Baltic Sea, a special, one might say local, phenomenon seems to have contributed to this.

In the cartographic representations of the air pressure, Figure 2, November 10th and 11th, there is a relatively small minimum over Putbus, Regenwalde, Rostock and Szczecin (Stettin) with an adjacent maximum. The minimum extending over Putbus - Regenwalde, the maximum over Rostock – Szczecin (Stettin), or from NW to SE.

On the two graphs for November 10th and 11th, the maximum exceeds the equal pressure line to the north and the minimum does not reach the next equal pressure line to the south.

That this minimum was able to influence the direction of the air masses moving above is shown by the four graphs of the air pressure. On the morning of November 10th, the wind directions west and south of this minimum were southwesterly, while in Regenwalde and Szczecin (Stettin) they were SE and ESE, respectively. That means the Equatorial Current moving southeast of the minimum was forced to make a 90° turn and follow the direction of the minimum, as a result of the air's effort to return to equilibrium. However, since the air flowed incessantly from the south-west towards the minimum, the minimum had caused its own air flow from the SE to the NW, and, considered separately, indirectly resisted the air flow blowing from the SW, or rather accumulated it, meeting at 90°, the relative maximum located directly southwest of the minimum can be explained.

The same conditions at the same place are noticeable on the other three days, although less pronounced on November 12th and 13th.

The causes of these peculiar air pressure conditions are not discernible.

On the morning of November 10th, when the area under discussion - with the relative minimum - lay inside the Equatorial Current, the Polar Current penetrating the lower layers lifted the Equatorial Current with its light air and an upward flow of air therefore occurred at the place in question. But since, as commented before, still on the morning of November 13th, the characteristics of the minimum and the maximum - in relative importance – after the cold heavy air of the Polar Current had flown over it already for two days and such an insignificant space of the air would have been balanced very soon, or this relative minimum would have changed in its position, we have to be satisfied with the fact of the existence of this relatively low air pressure in the direction of Putbus – Regenwalde.

Nevertheless, it must be emphasized that this local minimum must have given reason to increase the speed of the heavy cold polar air approaching from the NE. Furthermore, the development of the hurricane, which is reported by the pilot stations, started at Colberg and extended towards Kiel, must certainly be regarded as a related phenomenon.

3.2 The Relative Values of Air Pressure and Temperature together with the Wind Movement

If the preceding discussion covered the area of Central and Northern Europe, the meteorological observation material submitted by the governments from stations near the Prussian coasts of the Baltic and North Seas is, for the sake of completeness, combined into an overall picture to show the situation and changes of the atmosphere, especially on the coasts where the storm surge occurred.

In that discussion, the absolute observation material of the four stormy days was discussed, while in the following, the relative observation material, related to the mean barometer and thermometer readings of 20 days, namely from November 1st to November 20th, 1872, is treated.

The material used here consists of the observations of the barometer, thermometer, wind direction and wind intensity made at the individual stations at 6 a.m., 2 p.m. and 10 p.m.

Analogous to the principle of deviations from the normal state, the deviations of the air pressure as well as of the temperature of the respective stations and the corresponding period, are compiled in figures in the following Table 1,Table 2 and Table 3. The calculations were made for the respective locations and the corresponding time according to Dove, in the case of the barometer for the month of November, and in the case of the thermometer for each of the 5 days of the month of November. The used mean values are added in a clear manner, so that the absolute value can be reconstructed from the mean and the deviation. In addition, the wind directions in a wind rose divided into 16 parts and finally the wind intensities by numbers in gradations from 0 to 5 are calculated and compiled in the following tables (see Table 1 to Table 3). In these tables, the meteorological stations follow their geographical position from west to east; the times continuously from top to bottom.

In order to obtain the observations of a place contained in a main column also pictorially, graphical profile representations were made for each station. They were put together in Figure 5, Figure 6, Figure 7 and Figure 8.

Table 1: Observations and Mean Values of Air Pressure and Temperature as well as Wind Direction and Force at Emden, Sylt, Altona, Kiel and Lübeck between November 1st and 20th, 1872, at 6 a.m.; 2 p.m. and 10 p.m.

Tabelle I.

Emden.

Jahr und Monat	Datum	Tageszeit	Stunde	Bar.-Mitt.	Reduc. Bar.-Stand	Temp.-Mitt.	Reduc. Temperat.	Wind-richtung.	Stärke.
1872 November	1	Morg.	6	336,71 Pariser Linien	−2,0	+5,76	−0,4	SW	1
		Mitt.	2		−1,8		+2,8	SW	1
		Abd.	10		−4,2		+1,9	WSW	2
	2	Morg.	6		−5,2	+5,15	+1,8	WSW	2
		Mitt.	2		−5,1		+3,9	S	1
		Abd.	10		−6,3		+2,7	SW	1
	3	Morg.	6		−6,5		+0,2	SW	2
		Mitt.	2		−4,2		+2,7	W	1
		Abd.	10		−1,2		+0,5	NW	2
	4	Morg.	6		+1,1		+0,3	WSW	1
		Mitt.	2		+2,0		+2,8	W	1
		Abd.	10		+1,8		−0,9	—	0
	5	Morg.	6		−1,7		+1,0	S	2
		Mitt.	2		−2,3		+3,5	SW	1
		Abd.	10		−1,0		+4,1	SW	1
	6	Morg.	6		−0,1		+2,8	SW	1
		Mitt.	2		−0,1		+4,2	SW	2
		Abd.	10		−1,3		+5,6	SW	1
	7	Morg.	6		+1,2	+4,38	+3,1	SW	2
		Mitt.	2		+2,2		+4,7	W	2
		Abd.	10		+3,6		+2,9	WSW	2
	8	Morg.	6		+3,8		+0,9	SW	1
		Mitt.	2		+2,8		+3,4	SW	1
		Abd.	10		+2,1		+2,7	SW	1
	9	Morg.	6		+1,9		+0,3	WSW	1
		Mitt.	2		+1,9		+3,3	WSW	1
		Abd.	10		−1,6		+2,0	WSW	1
	10	Morg.	6		−3,9		+1,1	W	1
		Mitt.	2		−4,0		+3,7	W	1
		Abd	10		−3,8		−0,6	—	0
	11	Morg.	6		−2,7		−2,3	—	0
		Mitt.	2		−2,2		+1,1	NO	1
		Abd.	10		−1,0		−0,9	NO	1
	12	Morg.	6		+0,4	+2,67	+1,1	NO	2
		Mitt.	2		+0,8		+1,0	NO	2
		Abd.	10		+1,6		−1,0	NO	3
	13	Morg.	6		+0,1		−3,0	NNO	2
		Mitt.	2		−2,5		−2,7	NNO	3
		Abd.	10		−2,3		−2,0	O	2
	14	Morg.	6		−0,1		−3,4	O	1
		Mitt.	2		+0,6		±0	O	1
		Abd.	10		+1,4		−3,0	O	1
	15	Morg.	6		−1,1		+2,0	NNO	1
		Mitt.	2		−1,7		+1,2	SSO	1
		Abd.	10		−0,8		−1,4	SO	1
	16	Morg.	6		+0,9		−3,1	OSO	1
		Mitt.	2		+1,1		0,1	O	1
		Abd.	10		+0,9		−2,7	OSO	1
	17	Morg.	6		+0,4	+1,90	−1,9	SO	1
		Mitt.	2		−0,4		−0,6	O	1
		Abd.	10		−1,3		−1,6	O	1
	18	Morg.	6		−2,4		−0,9	O	1
		Mitt.	2		−2,7		+1,1	S	1
		Abd.	10		−4,3		+0,9	SO	1
	19	Morg.	6		−7,1		−0,8	O	1
		Mitt.	2		−5,5		+1,1	—	0
		Abd.	10		−4,3		−0,2	—	0
	20	Morg.	6		−5,2		+3,6	SW	1
		Mitt.	2		−3,4		+4,2	SW	1
		Abd.	10		−2,3		+3,7	SW	1

Sylt.

Datum	Tageszeit	Stunde	Bar.-Mitt.	Reduc. Bar.-Stand	Temp.-Mitt.	Reduc. Temperat.	Wind-richtung.	Stärke.
1	Morg.	6	336,43 Pariser Linien	−5,0	fehlt	—	WSW	2
	Mitt.	2		−4,1		—	WSW	2
	Abd.	10		−4,3		—	WSW	2
2	Morg.	6		−7,6	+5,87°	+3,4	WSW	2
	Mitt.	2		−6,2		+3,5	WSW	2
	Abd.	10		−7,6		+2,7	WSW	—
3	Morg.	6		−8,8		+0,9	WSW	1
	Mitt.	2		−7,5		+2,5	WNW	1
	Abd.	10		−4,8		+1,7	WNW	2
4	Morg.	6		−2,0		+1,1	WNW	2
	Mitt.	2		−0,4		+1,7	WNW	2
	Abd.	10		−0,3		+1,2	WNW	1
5	Morg.	6		−2,6		+0,9	SW	2
	Mitt.	2		−4,4		+3,0	S	1
	Abd.	10		−3,9		+3,3	WSW	1
6	Morg.	6		−2,7		+2,5	WSW	1
	Mitt.	2		−2,7		+3,8	SSW	2
	Abd.	10		−4,1		+4,1	SW	2
7	Morg.	6		−3,1	+5,03°	+4,0	WSW	3
	Mitt.	2		−0,8		+4,0	W	3
	Abd.	10		+0,4		+3,6	NW	3
8	Morg.	6		+0,6		+3,6	W	2
	Mitt.	2		+0,4		+4,2	W	2
	Abd.	10		−0,2		+3,8	W	1
9	Morg.	6		−0,6		+2,2	W	2
	Mitt.	2		−1,1		+2,6	W	1
	Abd.	10		−1,6		+2,4	W	1
10	Morg.	6		−5,4		±0	—	0
	Mitt.	2		−5,4		+1,1	SW	1
	Abd	10		−4,3		−0,2	ONO	1
11	Morg.	6		−3,9		−1,0	NO	1
	Mitt.	2		−2,9		+1,1	NO	1
	Abd.	10		−1,6		−1,0	NO	2
12	Morg.	6		+0,2	+3,56°	−1,2	NO	2
	Mitt.	2		+0,9		−0,2	NO	2
	Abd.	10		+2,0		−2,6	NO	2
13	Morg.	6		+1,4		−3,6	NO	2
	Mitt.	2		−1,2		−3,6	NO	3
	Abd.	10		−1,8		−2,6	NO	3
14	Morg.	6		−0,5		−0,1	ONO	2
	Mitt.	2		+0,7		+0,4	O	1
	Abd.	10		+1,1		−1,0	O	2
15	Morg.	6		−0,7		+0,6	ONO	2
	Mitt.	2		−1,9		+1,4	ONO	2
	Abd.	10		−2,5		+1,2	ONO	1
16	Morg.	6		−0,1		−1,2	SSO	1
	Mitt.	2		+1,4		±0	SO	1
	Abd.	10		+1,5		−1,5	O	1
17	Morg.	6		−0,1	+2,21°	+1,3	O	1
	Mitt.	2		−2,4		+2,3	O	1
	Abd.	10		−1,7		+0,8	S	1
18	Morg.	6		−2,3		−0,6	SO	1
	Mitt.	2		−3,4		±0	OSO	1
	Abd.	10		−4,4		+0,3	OSO	1
19	Morg.	6		−5,5		−0,1	O	1
	Mitt.	2		−6,1		+0,6	O	1
	Abd.	10		−6,2		+1,0	O	1
20	Morg.	6		−6,1		+1,0	OSO	1
	Mitt.	2		−5,8		+4,2	SSW	1
	Abd.	10		−4,1		+4,2	SW	1

Altona.

Datum	Tageszeit	Stunde	Bar.-Mitt.	Reduc. Bar.-Stand	Temp.-Mitt.	Reduc. Temperat.	Wind-richtung.	Stärke.
1	Morg.	6	336,35 Pariser Linien	−2,2	+5,78	+0,9	SW	1
	Mitt.	2		−1,7		+4,1	SW	1
	Abd.	10		−3,2		+2,4	SW	0
2	Morg.	6		−4,1	+5,13	+3,6	S	1
	Mitt.	2		−3,9		+5,1	S	1
	Abd.	10		−5,7		+3,5	S	0
3	Morg.	6		−6,2		+2,1	S	2
	Mitt.	2		−5,0		+3,1	S	2
	Abd.	10		−2,5		+1,9	—	0
4	Morg.	6		+0,1		+0,3	SW	2
	Mitt.	2		+1,0		+2,3	W	2
	Abd.	10		+1,8		±0	—	0
5	Morg.	6		±0		−0,1	SSO	1
	Mitt.	2		−1,9		+2,7	SSO	1
	Abd.	10		−1,5		+4,8	—	0
6	Morg.	6		−0,3		+4,5	SW	1
	Mitt.	2		−0,3		+5,3	SW	1
	Abd.	10		−1,1		+5,2	—	0
7	Morg.	6		−0,1	+4,06	+5,1	SW	1
	Mitt.	2		+1,8		+5,5	W	1
	Abd.	10		+3,1		+2,9	—	0
8	Morg.	6		+3,7		+1,3	SW	1
	Mitt.	2		+3,0		+3,6	SW	1
	Abd.	10		+1,7		+3,7	—	0
9	Morg.	6		+1,4		+1,7	SW	1
	Mitt.	2		+1,0		+3,9	SW	1
	Abd.	10		−1,3		+1,2	—	0
10	Morg.	6		−3,7		+1,0	SW	1
	Mitt.	2		−4,5		+2,4	SW	1
	Abd	10		−3,8		+1,0	—	0
11	Morg.	6		−3,3		+0,9	N	1
	Mitt.	2		−2,7		+2,5	NO	1
	Abd.	10		−1,4		+0,4	—	0
12	Morg.	6		−0,4	+2,52	+1,2	N	1
	Mitt.	2		−0,2		+1,7	NNO	1
	Abd.	10		+0,8		−0,7	—	0
13	Morg.	6		−2,0		−2,0	N	2
	Mitt.	2		−4,1		+0,4	NO	3
	Abd.	10		−1,3		+0,2	—	0
14	Morg.	6		+0,4		−0,6	ONO	2
	Mitt.	2		+0,9		+2,9	O	2
	Abd.	10		+0,5		+0,9	—	0
15	Morg.	6		−1,6		+3,3	NO	1
	Mitt.	2		−1,8		+4,0	ONO	1
	Abd.	10		−0,2		−1,0	—	0
16	Morg.	6		+1,8		−1,9	OSO	1
	Mitt.	2		+2,3		+1,3	O	1
	Abd.	10		+2,1		±0	—	0
17	Morg.	6		+0,3	+1,62	+2,3	ONO	0
	Mitt.	2		−0,4		+2,8	ONO	1
	Abd.	10		−0,3		+1,3	—	0
18	Morg.	6		−1,1		−1,2	OSO	1
	Mitt.	2		−2,3		+1,2	OSO	1
	Abd.	10		−3,0		+0,6	—	0
19	Morg.	6		−5,1		+0,7	OSO	1
	Mitt.	2		−3,7		+2,1	SO	1
	Abd.	10		−4,0		+1,9	—	0
20	Morg.	6		−5,1		+1,7	SO	1
	Mitt.	2		−3,5		+6,0	SW	1
	Abd.	10		−1,9		+4,4	—	0

Kiel.

Datum	Tageszeit	Stunde	Bar.-Mitt.	Reduc. Bar.-Stand	Temp.-Mitt.	Reduc. Temperat.	Wind-richtung.	Stärke.
1	Morg.	6	336,52 Pariser Linien	−3,3	+5,79	−0,3	SW	
	Mitt.	2		−2,8		2,9	SW	
	Abd.	10		−3,3		+0,0	S	
2	Morg.	6		−5,2	+4,95	+3,1	SW	
	Mitt.	2		−4,6		+4,6	SW	
	Abd.	10		−6,2		+3,1	SSW	
3	Morg.	6		−7,2		+1,6	SW	
	Mitt.	2		−6,2		+1,6	—	0
	Abd.	10		−3,7		+1,3	W	
4	Morg.	6		−1,1		−0,1	W	
	Mitt.	2		+0,1		+2,3	W	
	Abd.	10		+1,0		−0,5	SW	
5	Morg.	6		−1,4		±0	SSW	
	Mitt.	2		−2,7		+1,5	SSW	
	Abd.	10		−2,7		+3,7	WSW	
6	Morg.	6		−1,4		+3,1	SW	
	Mitt.	2		−1,3		+4,8	SW	
	Abd.	10		−2,4		+5,0	SW	
7	Morg.	6		−1,4	+4,07	+4,1	WSW	
	Mitt.	2		+0,5		+4,9	SW	
	Abd.	10		+1,7		+2,9	SW	
8	Morg.	6		+2,3		+2,1	WSW	
	Mitt.	2		+1,6		+4,3	SW	
	Abd.	10		+0,9		+3,4	SW	
9	Morg.	6		+0,6		+1,3	SW	
	Mitt.	2		−0,6		+3,0	SW	
	Abd.	10		−1,8		+1,4	SW	
10	Morg.	6		−4,3		+0,1	S	
	Mitt.	2		−4,9		+1,7	SSW	
	Abd	10		−4,2		+0,	SSW	
11	Morg.	6		−3,6		+0,9	N	
	Mitt.	2		−2,5		+1,6	NO	
	Abd.	10		−1,5		+1,1	NO	
12	Morg.	6		±0	+2,62	+0,7	NO	
	Mitt.	2		+0,5		+1,0	ONO	
	Abd.	10		+1,6		−0,8	NO	
13	Morg.	6		−0,9		−2,4	NO	
	Mitt.	2		−2,8		−1,5	NO	
	Abd.	10		−1,5		+2,0	OSO	
14	Morg.	6		+0,5		+0,7	OSO	
	Mitt.	2		+1,1		+2,4	OSO	
	Abd.	10		+1,4		+1,6	ONO	
15	Morg.	6		−1,3		+3,2	O	
	Mitt.	2		−1,8		+4,2	OSO	
	Abd.	10		−2,0		+3,7	SO	
16	Morg.	6		+1,8		+1,4	SO	
	Mitt.	2		+2,4		+1,0	O	
	Abd.	10		+2,3		+0,4	O	
17	Morg.	6		+0,1	+1,82	+3,4	O	
	Mitt.	2		−0,9		+2,9	W	
	Abd.	10		−0,5		+1,2	SSW	
18	Morg.	6		−1,3		−0,6	SO	
	Mitt.	2		−2,6		+1,5	OSO	
	Abd.	10		−3,3		+1,0	SO	
19	Morg.	6		−4,8		+0,5	SO	
	Mitt.	2		−5,8		+1,8	SO	
	Abd.	10		−4,8		+2,0	OSO	
20	Morg.	6		−4,6		+1,6	SSO	
	Mitt.	2		−4,5		+4,3	WSW	
	Abd.	10		−2,6		+3,4	S	

Lübeck.

Datum	Tageszeit	Stunde	Bar.-Mitt.	Reduc. Bar.-Stand	Temp.-Mitt.	Reduc. Temperat.	Wind-richtung.	Stärke.
1	Morg.	6	335,84 Pariser Linien	−2,2	+5,27	+0,2	W	3
	Mitt.	2		−2,0		+4,0	W	2
	Abd.	10		−2,6		−0,2	W	2
2	Morg.	6		−4,4	+4,24	+4,1	WSW	3
	Mitt.	2		−4,0		+6,0	W	3
	Abd.	10		−5,2		+3,8	W	3
3	Morg.	6		−6,2		+1,8	W	3
	Mitt.	2		−5,0		+2,8	WSW	3
	Abd.	10		−4,1		+1,9	WSW	3
4	Morg.	6		−0,4		−0,2	W	1
	Mitt.	2		+0,3		+2,7	NW	2
	Abd.	10		+1,7		−1,2	NW	1
5	Morg.	6		+0,2		−0,7	W	2
	Mitt.	2		−1,7		+1,5	SW	2
	Abd.	10		−1,9		+4,9	SSW	1
6	Morg.	6		−0,9		+4,4	WSW	1
	Mitt.	2		−0,7		+5,8	W	1
	Abd.	10		−1,2		+5,6	WSW	3
7	Morg.	6		−1,2	+3,30	+5,9	W	3
	Mitt.	2		+0,9		+5,7	W	3
	Abd.	10		+2,7		+2,5	W	3
8	Morg.	6		+3,2		+1,4	W	1
	Mitt.	2		+2,7		+5,0	W	2
	Abd.	10		+1,4		+3,3	W	2
9	Morg.	6		+1,4		+0,5	W	1
	Mitt.	2		+0,2		+3,9	WNW	2
	Abd.	10		−0,8		+0,8	WNW	1
10	Morg.	6		−3,8		±0	W	1
	Mitt.	2		−4,6		+2,4	W	1
	Abd	10		−3,8		+1,0	—	0
11	Morg.	6		−3,3		+0,2	ONO	1
	Mitt.	2		−2,6		+1,8	ONO	2
	Abd.	10		−1,4		+0,7	ONO	2
12	Morg.	6		−0,7	+1,85	+1,8	ONO	3
	Mitt.	2		−0,1		+1,6	ONO	4
	Abd.	10		+0,8		−0,4	ONO	4
13	Morg.	6		−1,7		−1,4	ONO	4
	Mitt.	2		−3,6		+0,6	ONO	4
	Abd.	10		−1,0		+1,4	OSO	3
14	Morg.	6		+0,7		−0,7	OSO	1
	Mitt.	2		+1,0		+3,1	OSO	1
	Abd.	10		+1,2		+1,1	OSO	1
15	Morg.	6		−1,1		+2,9	OSO	1
	Mitt.	2		−1,9		+4,2	SO	1
	Abd.	10		−1,0		+1,1	SO	1
16	Morg.	6		+2,6		−2,0	SSW	1
	Mitt.	2		+2,5		+1,0	SSO	1
	Abd.	10		+2,6		−0,2	OSO	1
17	Morg.	6		±0	+0,99	+3,0	—	0
	Mitt.	2		−0,6		+3,3	W	1
	Abd.	10		±0		−0,8	W	1
18	Morg.	6		−0,5		−0,8	SW	1
	Mitt.	2		−2,3		+1,7	SSO	2
	Abd.	10		−2,6		+0,7	SSO	2
19	Morg.	6		−4,1		−0,2	OSO	2
	Mitt.	2		−5,5		+3,0	S	2
	Abd.	10		−3,8		+2,2	S	2
20	Morg.	6		−4,0		+1,8	S	2
	Mitt.	2		−3,8		+5,2	WSW	2
	Abd.	10		−1,9		+3,3	WSW	1

Table 2: Observations and Mean Values of Air Pressure and Temperature as well as Wind Direction and Force at Putbus, Swinoujscie (Swinemünde), Szczecin (Stettin), Regenwalde and Coeslin (Cöslin) between November 1st and 20th, 1872, at 6 a.m., 2 p.m. and 10 p.m.

Tabelle II.

Jahr und Monat	Datum	Tageszeit	Stunde	Putbus.					
				Bar.-Mitt.	Reduc. Bar.-Stand	Temp.-Mitt.	Reduc. Temperat.	Wind-richtung.	Stärke.
1872 November	1	Morg.	6		−4,4		−0,6	SW	3
		Mitt.	2		−4,0	+5,41	+3,1	—	3
		Abd.	10		−3,3		−0,7	SW	2
	2	Morg.	6		−5,3		+3,4	S	2
		Mitt.	2		−5,0		+6,3	SW	2
		Abd.	10		−6,7		+2,8	SO	2
	3	Morg.	6		−7,6		+2,8	S	2
		Mitt.	2		−7,4		+3,6	S	3
		Abd.	10		−6,1		+1,6	W	3
	4	Morg.	6		−4,8	+4,31	+2,0	W	3
		Mitt.	2		−2,2		+2,9	W	3
		Abd.	10		−1,2		−0,7	SW	2
	5	Morg.	6		−0,7		−1,0	S	1
		Mitt.	2		−2,7		+3,2	SO	2
		Abd.	10		−3,2		+1,7	SO	2
	6	Morg.	6		−2,1		+4,4	W	2
		Mitt.	2		−1,8		+5,0	SO	2
		Abd.	10		−2,3		+4,6	S	2
	7	Morg.	6		−2,5		+5,0	SW	3
		Mitt.	2		−1,1		+5,6	SW	3
		Abd.	10		+0,6		+1,8	SW	3
	8	Morg.	6		+0,8		+1,8	W	2
		Mitt.	2		+0,9		+4,8	SW	2
		Abd.	10		−0,5		+2,5	SW	2
	9	Morg.	6		−1,0	+3,54	+1,7	W	1
		Mitt.	2		−1,2		+3,7	SW	2
		Abd.	10		−3,7		±0	S	1
	10	Morg.	6		−4,7		+0,4	S	1
		Mitt.	2		−6,2		+1,0	SO	1
		Abd.	10		−6,0		−0,2	W	1
	11	Morg.	6	335,2 Pariser Linien	−5,0		+0,3	NW	1
		Mitt.	2		−4,3		+1,8	N	1
		Abd.	10		−2,9		+1,5	NO	2
	12	Morg.	6		−2,3		+2,1	N	2
		Mitt.	2		−1,8		+1,9	NO	3
		Abd.	10		−1,5		−0,3	NO	4
	13	Morg.	6		−4,6		−1,2	NO	5
		Mitt.	2		−3,9		+0,6	O	3
		Abd.	10		−1,0		+1,7	O	2
	14	Morg.	6		−0,3		+0,4	O	1
		Mitt.	2		+0,5	+2,43	+1,9	O	1
		Abd.	10		+0,3		+2,6	O	1
	15	Morg.	6		−1,7		+3,4	SO	2
		Mitt.	2		−1,9		+3,9	SO	2
		Abd.	10		−1,8		+4,5	SO	1
	16	Morg.	6		+0,9		−1,4	SO	1
		Mitt.	2		+1,8		+0,9	O	1
		Abd.	10		+0,5		+3,1	O	1
	17	Morg.	6		−1,3		+3,9	O	1
		Mitt.	2		−1,6		+1,9	O	1
		Abd.	10		−1,3		+2,7	O	1
	18	Morg.	6		−1,9		+0,3	O	1
		Mitt.	2		−2,7		+0,9	SO	1
		Abd.	10		−3,6		+1,3	SO	2
	19	Morg.	6		−4,8	+1,26	+0,7	SO	2
		Mitt.	2		−5,2		+2,5	SO	1
		Abd.	10		−5,1		+1,2	SO	1
	20	Morg.	6		−4,6		+1,4	SW	1
		Mitt.	2		−4,9		+2,4	S	1
		Abd.	10		−4,8		+3,5	W	1

Datum	Tageszeit	Stunde	Swinemünde (Leuchtthurm).					
			Bar.-Mitt.	Reduc. Bar.-Stand	Temp.-Mitt.	Reduc. Temperat.	Wind-richtung.	Stärke.
1	Morg.	6		−1,3		+1,3	WSW	2
	Mitt.	2		−1,0		+4,2	WSW	2
	Abd.	10		−0,9 −0,8		+3,2 +1,2	WSW	2
2	Morg.	6		−2,4		+2,2	SSW	2
	Mitt.	2		−2,1		+5,2	WSW	2
	Abd.	10		−2,0 −2,9		+4,2 +3,2	SW	2
3	Morg.	6		−3,4	+4,75	+3,2	SW	1
	Mitt.	2		−3,4		+3,2	WSW	3
	Abd.	10		−3,4 −2,4		+2,2 +2,2	SSW	2
4	Morg.	6		−1,2		+0,2	W	2
	Mitt.	2		+0,6		+2,7	NW	2
	Abd.	10		+1,2 +1,8		+1,2 +0,2	WNW	1
5	Morg.	6		+0,8		−0,8	SW	1
	Mitt.	2		+1,6		+2,2	SW	2
	Abd.	10		−0,3 −0,3		+1,2 +1,2	SW	1
6	Morg.	6		−0,5		+5,5	NW	1
	Mitt.	2		+0,5		+5,5	W	1
	Abd.	10		+0,4 +0,4		+6,5 +6,5	WSW	1
7	Morg.	6		−0,5		+5,5	WSW	3
	Mitt.	2		+1,4		+7,5	W	4
	Abd.	10		+1,5 +2,7		+5,5 +2,5	W	3
8	Morg.	6		+2,7		+2,5	W	1
	Mitt.	2		+2,6	+3,52	+4,5	WSW	3
	Abd.	10		+2,6 +1,6		+3,5 +3,5	WSW	2
9	Morg.	6		+1,7		+2,5	W	1
	Mitt.	2		+0,7		+2,5	W	1
	Abd.	10		+0,8 −0,2		+1,5 +0,5	W	1
10	Morg.	6		−1,2		+0,5	SO	1
	Mitt.	2		−2,2		+1,5	O	1
	Abd.	10		−3,2 −3,2		+1,0 +1,0	NO	1
11	Morg.	6	332,80 Pariser Linien	−2,2		+1,7	—	0
	Mitt.	2		−1,7		+2,2	NO	1
	Abd.	10		−1,2 −1,2		+2,2 +1,2	SO	1
12	Morg.	6		−1,2		+2,2	ONO	4
	Mitt.	2		−1,2		+2,2	ONO	4
	Abd.	10		−0,2 −2,1		+1,2 +0,2	ONO	4
13	Morg.	6		−2,1	+2,75	+0,2	ONO	5
	Mitt.	2		−1,1		+0,2	O	4
	Abd.	10		−1,0 +1,0		+0,8 −0,8	O	4
14	Morg.	6		+1,9		−0,2	OSO	1
	Mitt.	2		+2,3		+2,2	SO	1
	Abd.	10		+2,3 +1,8		+2,2 +2,2	OSO	1
15	Morg.	6		+0,7		+3,2	SO	1
	Mitt.	2		−0,4		+4,2	SO	1
	Abd.	10		−0,4 +0,6		+5,2 +4,2	OSO	1
16	Morg.	6		+2,8		+2,1	SSW	1
	Mitt.	2		+2,7		+4,1	SW	1
	Abd.	10		+2,8 +2,8		+3,1 +3,1	OSO	1
17	Morg.	6		+1,8		+2,1	SO	1
	Mitt.	2		+0,8		+2,1	SSO	1
	Abd.	10		+0,9 +0,3		+1,1 +2,1	SSO	1
18	Morg.	6		+1,0		−0,9	SSW	1
	Mitt.	2		+1,0	+1,91	+0,1	SSW	1
	Abd.	10		−0,1 −1,0		+1,1 +0,1	SSW	1
19	Morg.	6		−2,0		−0,9	SSO	1
	Mitt.	2		−2,2		+2,1	SSO	1
	Abd.	10		−3,1 −2,6		+1,6 +1,1	SSO	1
20	Morg.	6		−2,0		+0,1	SW	1
	Mitt.	2		−2,2		+2,1	SSO	1
	Abd.	10		−1,2 −0,2		+3,1 +3,1	SSW	1

Datum	Tageszeit	Stunde	Stettin.					
			Bar.-Mitt.	Reduc. Bar.-Stand	Temp.-Mitt.	Reduc. Temperat.	Wind-richtung.	Stärke.
1	Morg.	6		−1,7		+0,5	W	1
	Mitt.	2		−1,8	+5,51	+4,2	W	1
	Abd.	10		−1,4		−0,1	WSW	1
2	Morg.	6		−3,1		+1,7	SW	1
	Mitt.	2		−3,6		+6,1	SW	1
	Abd.	10		−3,3		+2,5	SW	1
3	Morg.	6		−5,1		+2,5	SW	2
	Mitt.	2		−4,8		+4,2	WSW	2
	Abd.	10		−4,1		+1,9	WSW	1
4	Morg.	6		−1,8	+4,50	+0,9	W	1
	Mitt.	2		−0,2		+3,5	WNW	2
	Abd.	10		+1 4		−1,1	W	2
5	Morg.	6		+1,4		−1,5	SW	1
	Mitt.	2		−0,6		+1,9	SSW	2
	Abd.	10		−1,0		+1,1	SW	1
6	Morg.	6		−0,6		+2,6	W	1
	Mitt.	2		+0,2		+5,9	W	1
	Abd.	10		+0,3		+3,7	W	2
7	Morg.	6		−0,2		+5,8	W	2
	Mitt.	2		+1,0		+6,8	WNW	2
	Abd.	10		+2,7		+2,6	W	2
8	Morg.	6		+3,1		+1,0	W	2
	Mitt.	2		+3,0		+4,7	W	2
	Abd.	10		+2,0		+2,7	SSW	2
9	Morg.	6		+1,0	+3,40	+2,0	WSW	1
	Mitt.	2		+0,5		+4,8	W	2
	Abd.	10		−0,5		+0,2	NW	1
10	Morg.	6		−3,3		+1,2	O	1
	Mitt.	2		−5,3		+1,2	O	2
	Abd.	10		−4,8		±0	N	1
11	Morg.	6	337,0 Pariser Linien	−4,1		−0,2	NO	1
	Mitt.	2		−3,3		+2,4	NO	2
	Abd.	10		−2,5		+0,4	NO	1
12	Morg.	6		−2,1		+0,9	NO	1
	Mitt.	2		−1,6		+1,6	ONO	2
	Abd.	10		−2,3		+0,7	NNO	4
13	Morg.	6		−4,9		−2,0	O	4
	Mitt.	2		−3,3		+1,7	O	3
	Abd.	10		−0,3		+0,5	O	2
14	Morg.	6		+0,7		+0,9	O	1
	Mitt.	2		+1,2	+2,39	+2,5	OSO	2
	Abd.	10		+1,3		+2,5	NO	1
15	Morg.	6		−0,6		+2,9	OSO	3
	Mitt.	2		−0,8		+5,1	OSO	2
	Abd.	10		0,5		+4,9	SO	2
16	Morg.	6		+2,3		+1,1	SSW	2
	Mitt.	2		+3,0		+1,8	OSO	2
	Abd.	10		+1,8		+2,2	O	1
17	Morg.	6		+0,2		+2,8	O	1
	Mitt.	2		−0,1		+1,9	OSO	2
	Abd.	10		+0,5		+3,0	OSO	1
18	Morg.	6		±0		−0,2	SO	1
	Mitt.	2		−1,0		+2,4	SSO	2
	Abd.	10		−1,8		+0,4	S	1
19	Morg.	6		−3,3	+0,97	−1,3	SO	2
	Mitt.	2		−3,6		+2,2	O	2
	Abd.	10		−3,8		+2,0	OSO	1
20	Morg.	6		−3,1		+1,4	SO	1
	Mitt.	2		−3,0		+3,6	SW	2
	Abd.	10		−1,2		+3,7	S	1

Datum	Tageszeit	Stunde	Regenwalde.					
			Bar.-Mitt.	Reduc. Bar.-Stand	Temp.-Mitt.	Reduc. Temperat.	Wind-richtung.	Stärke.
1	Morg.	6		−4,5		±0	SW	0
	Mitt.	2		−4,5	+4,97	+4,0	SW	2
	Abd.	10		−3,0		−1,2	SW	0
2	Morg.	6		−5,0		+1,9	S	2
	Mitt.	2		−6,2		+6,5	SW	1
	Abd.	10		−6,8		+3,3	SW	0
3	Morg.	6		−8,1		+2,9	SW	1
	Mitt.	2		−8,0		+4,7	SW	2
	Abd.	10		−6,4		+2,5	SW	2
4	Morg.	6		−4,6	+4,12	+1,3	W	2
	Mitt.	2		−3,2		+3,9	W	2
	Abd.	10		−0,9		−0,7	W	2
5	Morg.	6		−0,9		−1,5	W	0
	Mitt.	2		−3,6		+2,3	S	1
	Abd.	10		−6,0		+1,6	SW	1
6	Morg.	6		−3,0		+1,9	SW	0
	Mitt.	2		−2,5		+6,1	SW	1
	Abd.	10		−2,2		+4,1	SW	0
7	Morg.	6		−3,1		+5,8	W	3
	Mitt.	2		−2,2		+6,0	W	3
	Abd.	10		+0,4		+1,6	W	1
8	Morg.	6		+1,1		±0	SW	2
	Mitt.	2		+0,4		+4,4	SW	2
	Abd.	10		−0,5		+2,1	SW	2
9	Morg.	6		−1,5	+3,97	+1,8	WSW	2
	Mitt.	2		−2,5		+3,6	W	1
	Abd.	10		−3,7		−1,0	W	0
10	Morg.	6		−6,1		±0	SO	0
	Mitt.	2		−7,6		−0,6	O	2
	Abd.	10		−8,1		−0,8	O	2
11	Morg.	6	336,0 Pariser Linien	−6,0		−1,6	O	0
	Mitt.	2		−5,1		+1,0	O	2
	Abd.	10		−4,5		±0	NO	3
12	Morg.	6		−3,4		+1,2	NO	2
	Mitt.	2		−3,0		+1,4	NO	3
	Abd.	10		−3,4		+0,4	NO	4
13	Morg.	6		−5,2		−1,6	NO	4
	Mitt.	2		−4,0		−0,6	NO	3
	Abd.	10		−0,8		−0,2	NO	2
14	Morg.	6		−0,3		+0,6	O	1
	Mitt.	2		+0,8	+2,00	+2,0	SO	1
	Abd.	10		+0,1		+3,8	SO	2
15	Morg.	6		−1,4		+3,6	SO	2
	Mitt.	2		−2,5		+6,3	SO	1
	Abd.	10		−2,6		+6,4	O	2
16	Morg.	6		+0,5		+1,4	SO	0
	Mitt.	2		+0,6		+1,6	S	0
	Abd.	10		−1,2		+3,2	O	1
17	Morg.	6		−1,9		±0	SO	0
	Mitt.	2		−2,4		+2,2	SO	1
	Abd.	10		−1,5		+3,0	SO	0
18	Morg.	6		−1,9		±0	SO	0
	Mitt.	2		−3,0		+3,6	SSO	0
	Abd.	10		−2,9		−0,2	SO	0
19	Morg.	6		−4,4	+0,41	−0,8	SO	0
	Mitt.	2		−4,9		+2,4	SO	0
	Abd.	10		−5,4		+0,6	SO	0
20	Morg.	6		−4,4		+1,8	SW	0
	Mitt.	2		−4,4		+3,8	S	0
	Abd.	10		−3,5		+4,6	S	0

Datum	Tageszeit	Stunde	Cöslin.					
			Bar.-Mitt.	Reduc. Bar.-Stand	Temp.-Mitt.	Reduc. Temperat.	Wind-richtung.	Stärke.
1	Morg.	6		−1,9		−0,9	SW	1
	Mitt.	2		−1,5	+4,88	+3,5	SW	1
	Abd.	10		−0,6		−1,4	SW	1
2	Morg.	6		−2,6		+3,3	S	1
	Mitt.	2		−2,7		+6,3	SW	1
	Abd.	10		−2,8		+3,4	SW	1
3	Morg.	6		−4,3		+3,0	SW	1
	Mitt.	2		−4,2		+4,4	SW	1
	Abd.	10		−3,6		+2,3	SW	1
4	Morg.	6		−2,1	+3,97	+1,0	W	1
	Mitt.	2		−0,7		+1,9	W	1
	Abd.	10		+0,7		+0,8	NW	1
5	Morg.	6		+1,4		−3,0	SW	1
	Mitt.	2		+0,6		+1,7	SW	1
	Abd.	10		−0,1		+0,5	SW	1
6	Morg.	6		−0,3		+1,5	SW	1
	Mitt.	2		+0,4		+5,2	NW	1
	Abd.	10		+0,5		+3,5	SW	1
7	Morg.	6		−0,6		+6,3	SW	3
	Mitt.	2		+0,8		+6,2	NW	1
	Abd.	10		+2,1		+3,0	NW	1
8	Morg.	6		+2,8		+1,6	W	1
	Mitt.	2		+2,8		+5,0	W	1
	Abd.	10		+2,1	+3,00	+2,6	W	1
9	Morg.	6		+0,8		+1,8	W	1
	Mitt.	2		+0,6		+4,5	W	1
	Abd.	10		±0		−0,4	W	1
10	Morg.	6		−2,4		−1,0	S	1
	Mitt.	2		−4,5		+1,0	O	1
	Abd.	10		−5,2		−0,6	O	1
11	Morg.	6	336,1 Pariser Linien	−3,8		−2,0	N	1
	Mitt.	2		−2,8		+3,0	NO	1
	Abd.	10		−2,1		+0,9	NO	1
12	Morg.	6		−1,3		+2,0	NO	1
	Mitt.	2		−0,6		+1,4	NO	2
	Abd.	10		−1,7		+0,5	NO	4
13	Morg.	6		−2,9		−1,3	ONO	3
	Mitt.	2		−1,2		−1,3	O	3
	Abd.	10		+0,9		−0,4	O	3
14	Morg.	6		+1,9		+0,5	SO	1
	Mitt.	2		+2,0	+1,32	+1,9	SO	1
	Abd.	10		+2,6		+4,1	SO	3
15	Morg.	6		+1,1		+4,7	SO	3
	Mitt.	2		+0,5		+7,7	SO	3
	Abd.	10		+0,6		+6,9	SO	3
16	Morg.	6		+2,9		+2,6	SW	1
	Mitt.	2		+3,8		+3,1	SW	1
	Abd.	10		+3,1		+3,7	SW	1
17	Morg.	6		+1,7		−0,6	SO	1
	Mitt.	2		+0,9		+1,1	S	3
	Abd.	10		+1,1		+2,0	S	1
18	Morg.	6		+0,5		+2,2	S	1
	Mitt.	2		−0,4		+3,8	S	1
	Abd.	10		−0,8	+0,55	+1,4	S	1
19	Morg.	6		−2,2		+0,3	S	1
	Mitt.	2		−2,8		+2,8	S	1
	Abd.	10		−3,0		+1,5	S	1
20	Morg.	6		−2,5		+1,4	SO	1
	Mitt.	2		−2,0		+3,4	S	1
	Abd.	10		−1,1		+4,2	S	1

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Table 3: Observations and Mean Values of Air Pressure and Temperature as well as Wind Direction and Force at Lauenburg, Gdansk (Danzig), Koenigsberg (Königsberg) and Memel between November 1st and 20th, 1872, at 6 a.m., 2 p.m. and 10 p.m.

Tabelle III.

Jahr und Monat	Datum	Tageszeit	Stunde	Lauenburg.						Danzig.					
				Bar.-Mitt.	Reduc. Bar.-Stand	Temp.-Mitt.	Reduc. Temperat.	Wind-richtung.	Stärke.	Bar.-Mitt.	Reduc. Bar.-Stand	Temp.-Mitt.	Reduc. Temperat.	Wind-richtung.	Stärke.
1872 November	1	Morg.	6		−3,0			W	3		−3,5		+0,6	W	1
		Mitt.	2		−2,6			W	2		−3,1	+5,23	+3,1	W	2
		Abd.	10		−1,5			W	1		−1,8		+0,5	WSW	1
	2	Morg.	6		−2,6		+2,5	S	2		−2,7		−1,3	SSW	1
		Mitt.	2		−2,8		+5,9	W	2		−3,2		+5,8	SW	1
		Abd.	10		−3,0		+2,1	W	1		−3,2		+1,7	SW	1
	3	Morg.	6		−4,9		+2,9	S	2		−5,9		+0,9	S	1
		Mitt.	2		−4,9		+3,9	W	2		−6,4		+3,7	SW	1
		Abd.	10		−4,5		+2,5	W	2		−4,7		+0,5	SW	1
	4	Morg.	6		−3,6	+4,26	+1,6	W	2		−4,2	+4,53	+1,7	WSW	1
		Mitt.	2		−2,1		+1,7	W	2		−2,7		+1,9	WNW	1
		Abd.	10		−0,5		+0,1	W	1		−1,1		−0,1	WNW	2
	5	Morg.	6		+0,2		−1,1	WSW	2		−0,4		−1,4	NW	1
		Mitt.	2		+0,3		+1,1	SW	2		−0,2		+0,6	W	1
		Abd.	10		−0,4		+0,5	SW	1		−0,7		−2,2	SW	1
	6	Morg.	6		−1,0		+0,8	S	0		−1,3		−1,0	S	1
		Mitt.	2		−0,5		+3,6	SSW	2		−0,8		+1,8	S	1
		Abd.	10		−0,4		+3,5	SSW	2		−0,6		+2,5	SSW	1
	7	Morg.	6		−1,9		+6,7	SW	3		−2,1		+5,3	SW	2
		Mitt.	2		−0,2		+6,4	W	3		−0,9		+6,4	WNW	2
		Abd.	10		+0,9		+3,5	W	2		+0,4		+3,3	WNW	2
	8	Morg.	6		+1,3		+2,8	W	3		+0,8		+2,9	WNW	2
		Mitt.	2		+1,8		+4,5	W	2		+1,3		+4,3	W	2
		Abd.	10		+1,0		+3,2	W	2		+0,5		+2,5	W	2
	9	Morg.	6		−0,5	+2,87	+3,0	W	2		−0,9	+3,26	+2,3	WSW	2
		Mitt.	2		−0,2		+3,7	W	1		−0,8		+3,9	W	1
		Abd.	10		−1,0		+0,9	W	1		−1,4		−0,6	WSW	1
	10	Morg.	6		−2,5		−0,8	SSO	1		−2,8		−1,8	S	1
		Mitt.	2		−4,8		+1,2	OSO	2		−5,1		+1,0	SO	1
		Abd.	10		−6,2		+0,4	OSO	1		−6,8		+0,5	SO	2
	11	Morg.	6	336,36 Pariser Linien	−5,4		+0,1	NO	0	337,2 Pariser Linien	−6,5		+0,9	NNO	2
		Mitt.	2		−3,8		+2,2	NO	2		−4,7		+2,1	NNO	2
		Abd.	10		−2,6		+1,6	NO	3		−3,2		+1,1	NO	1
	12	Morg.	6		−2,0		+1,2	NO	3		−2,7		+2,2	NO	3
		Mitt.	2		−1,0		+0,5	NO	3		−2,0		+1,0	ONO	3
		Abd.	10		−0,9		−1,6	NO	3		−1,5		−1,2	ONO	3
	13	Morg.	6		−2,3		−2,5	O	4		−2,3		−2,8	ONO	3
		Mitt.	2		−0,8		−1,9	O	2		−0,8		−2,0	O	3
		Abd.	10		+1,2		−1,4	O	2		+0,8		−1,5	OSO	3
	14	Morg.	6		+1,6	+2,46	−1,4	O	2		+1,4		−1,1	SO	1
		Mitt.	2		+2,9		+2,1	SO	1		+2,5	+1,82	+1,7	SSO	1
		Abd.	10		+2,8		+1,2	SO	1		+2,9		+0,5	SSO	1
	15	Morg.	6		+1,6		+2,3	SO	3		+1,8		+1,6	SO	1
		Mitt.	2		+1,0		+4,8	SO	2		+1,0		+4,4	SO	1
		Abd.	10		+0,8		+4,5	SO	2		+0,8		+4,9	SO	1
	16	Morg.	6		+1,9		+4,7	SW	1		+1,6		+4,4	S	1
		Mitt.	2		+3,3		+3,6	SW	1		+2,8		+5,1	S	1
		Abd.	10		+2,6		+3,5	SW	1		+2,4		+2,4	SO	1
	17	Morg.	6		+1,3		−0,8	OSO	2		+1,2		−1,2	OSO	1
		Mitt.	2		+0,8		+2,0	OSO	1		+0,6		+1,6	SO	2
		Abd.	10		+0,9		+1,3	OSO	1		+0,6		+0,8	SSO	1
	18	Morg.	6		+0,1		+1,4	SO	1		±0		+0,8	SSO	1
		Mitt.	2		−0,4		+1,5	SO	2		−0,8		+1,3	S	1
		Abd.	10		−1,0		+0,5	SO	1		−1,2		+0,1	S	1
	19	Morg.	6		−2,4	+1,24	−0,2	SO	1		−2,8		−0,8	S	1
		Mitt.	2		−2,9		+0,9	SO	1		−2,9	+1,00	+0,2	S	1
		Abd.	10		−3,3		+2,0	SO	1		−3,4		+0,7	SSW	1
	20	Morg.	6		−3,2		+1,6	SW	1		−3,7		+1,6	SSW	1
		Mitt.	2		−2,3		+2,7	SW	1		−2,6		+2,9	SW	1
		Abd.	10		−1,6		+3,9	SW	1		−1,9		+2,8	S	1

Jahr und Monat	Datum	Königsberg.						Memel.					
		Bar.-Mitt.	Reduc. Bar.-Stand	Temp.-Mitt.	Reduc. Temperat.	Wind-richtung.	Stärke.	Bar.-Mitt.	Reduc. Bar.-Stand	Temp.-Mitt.	Reduc. Temperat.	Wind-richtung.	Stärke.
1872 November	1		−2,9	+4,47	−1,2	SO	3		−4,9	+4,58	+3,6	W	3
	2		−1,8		+0,4	SO	1		−1,8		+3,5	SW	1
	3		−4,0		+2,1	SO	1		−4,0		+1,7	SO	1
	4		−3,6	+3,67	+1,7	SW	3		−4,7	+4,03	+3,2	SW	1
	5		−0,4		+1,3	W	3		−1,2		+2,2	W	1
	6		−0,3		−0,5	SO	1		±0		−1,4	SO	1
	7		−1,8		+6,3	SW	4		−2,0		+5,8	S	1
	8		+0,7		+3,6	SW	3		−0,4		+5,3	W	3
	9		−0,7	+2,20	+3,0	SW	3		−1,4	+2,53	+4,3	W	1
	10		−2,4		+1,0	S	1		−2,4		+1,9	S	1
	11	336,8 Pariser Linien	−5,9		+1,0	SW	1	337,0 Pariser Linien	−6,1		+1,0	O	0
	12		−2,2		+1,2	O	3		−1,0		+0,5	NO	1
	13		−1,3		−5,5	NO	4		+0,5		−5,7	NO	3
	14		+2,7	+1,08	−1,2	SO	1		+3,3	+1,68	−4,7	O	2
	15		+3,1		+1,3	SO	1		+1,2		−0,7	O	1
	16		+2,7		+4,1	SO	1		+3,3		+1,9	SO	1
	17		+2,3		−0,6	SO	3		+3,3		−0,9	O	1
	18		+1,1		−1,2	SO	1		+2,0		−1,3	SO	1
	19		−2,1	−0,01	+0,3	SO	1		−1,1	+0,65	±0	O	1
	20		−2,6		+1,6	SO	1		−2,4		+1,9	SO	1

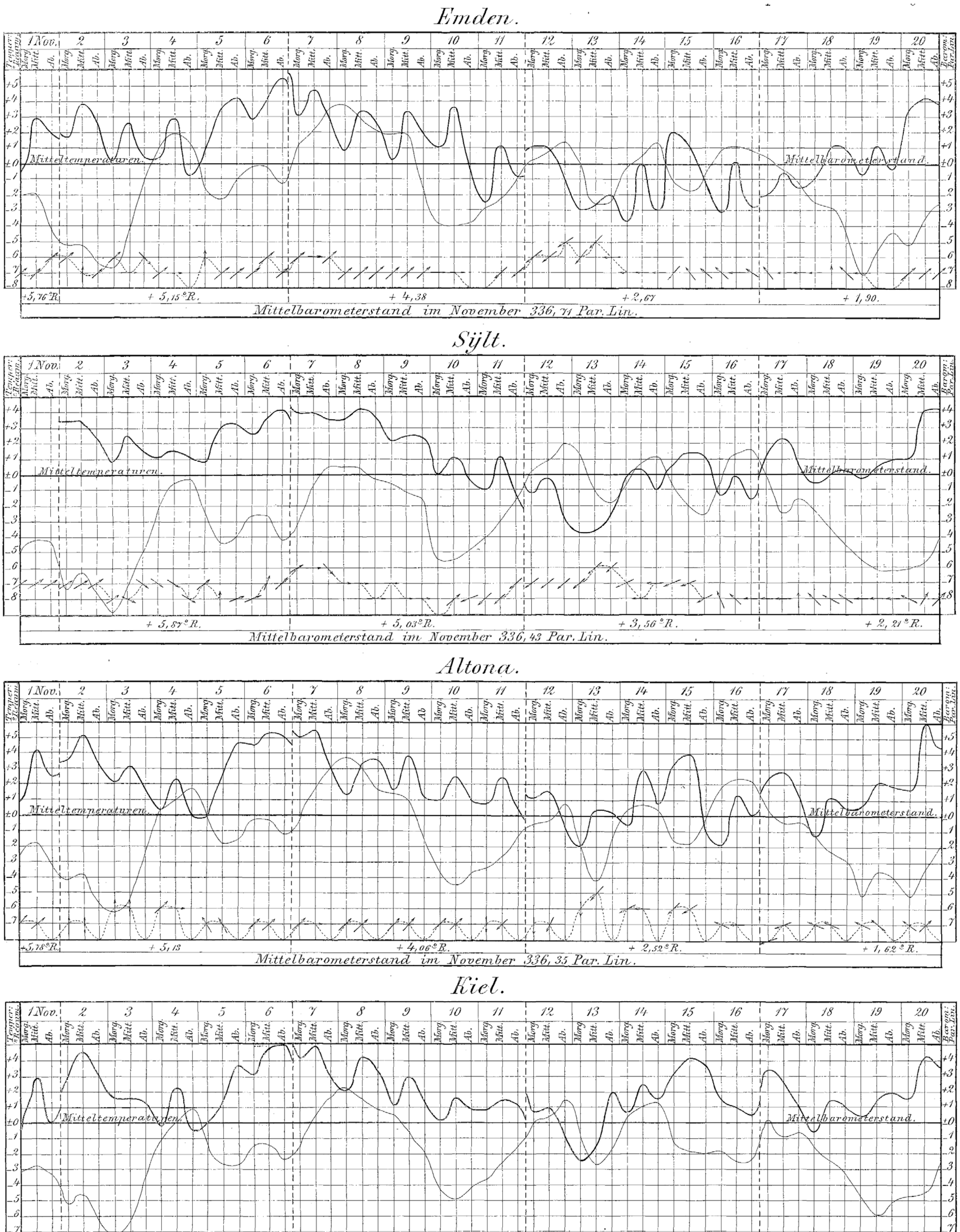

Figure 5: Storm surge of November 12th–13th, 1872, at the Baltic Sea, Graphical Representation of the Meteorological Tables, Table 1, Table 2, Table 3.

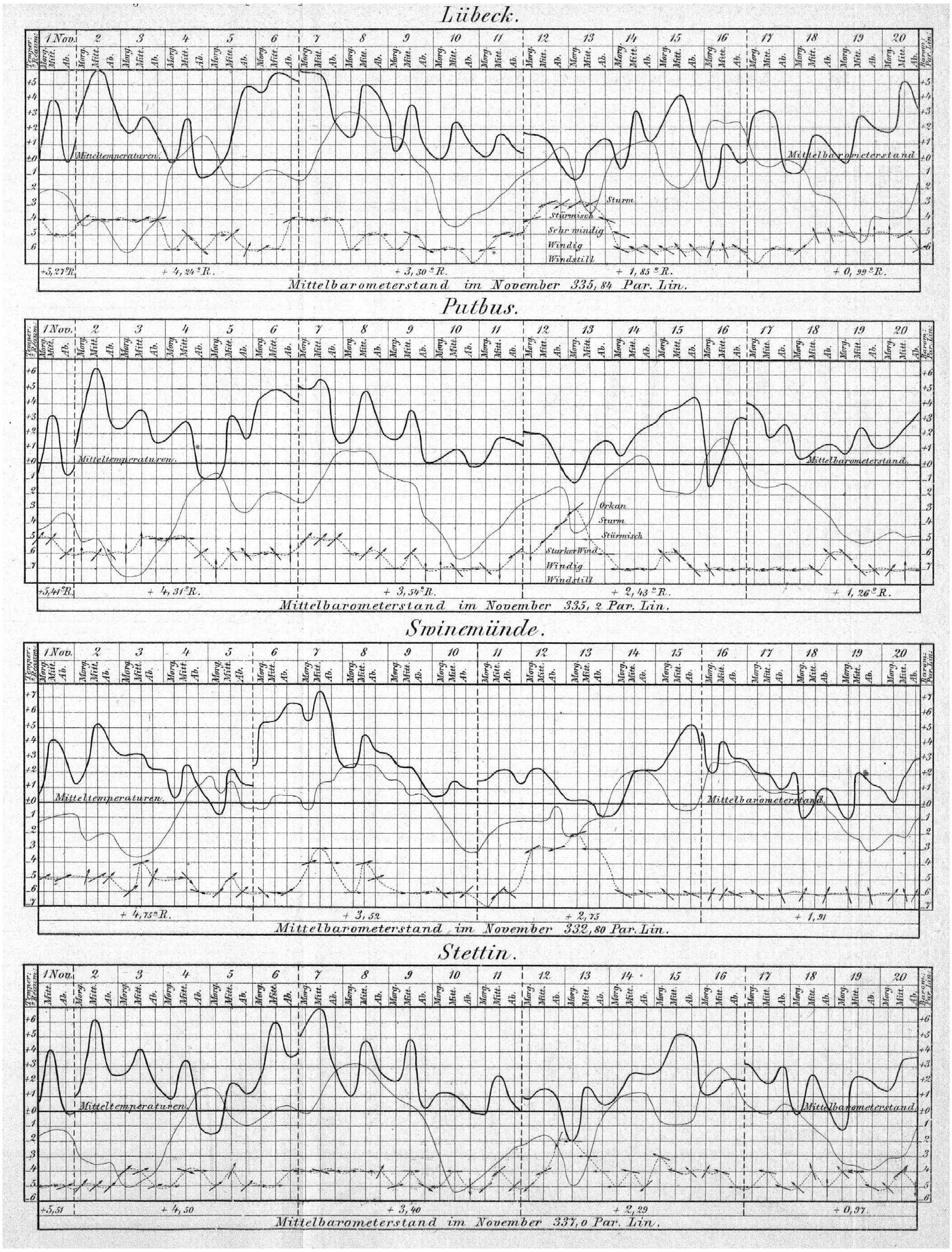

Figure 6: Storm surge of November 12th–13th, 1872, at the Baltic Sea, Graphical Representation of the Meteorological Tables, Table 1, Table 2, Table 3.

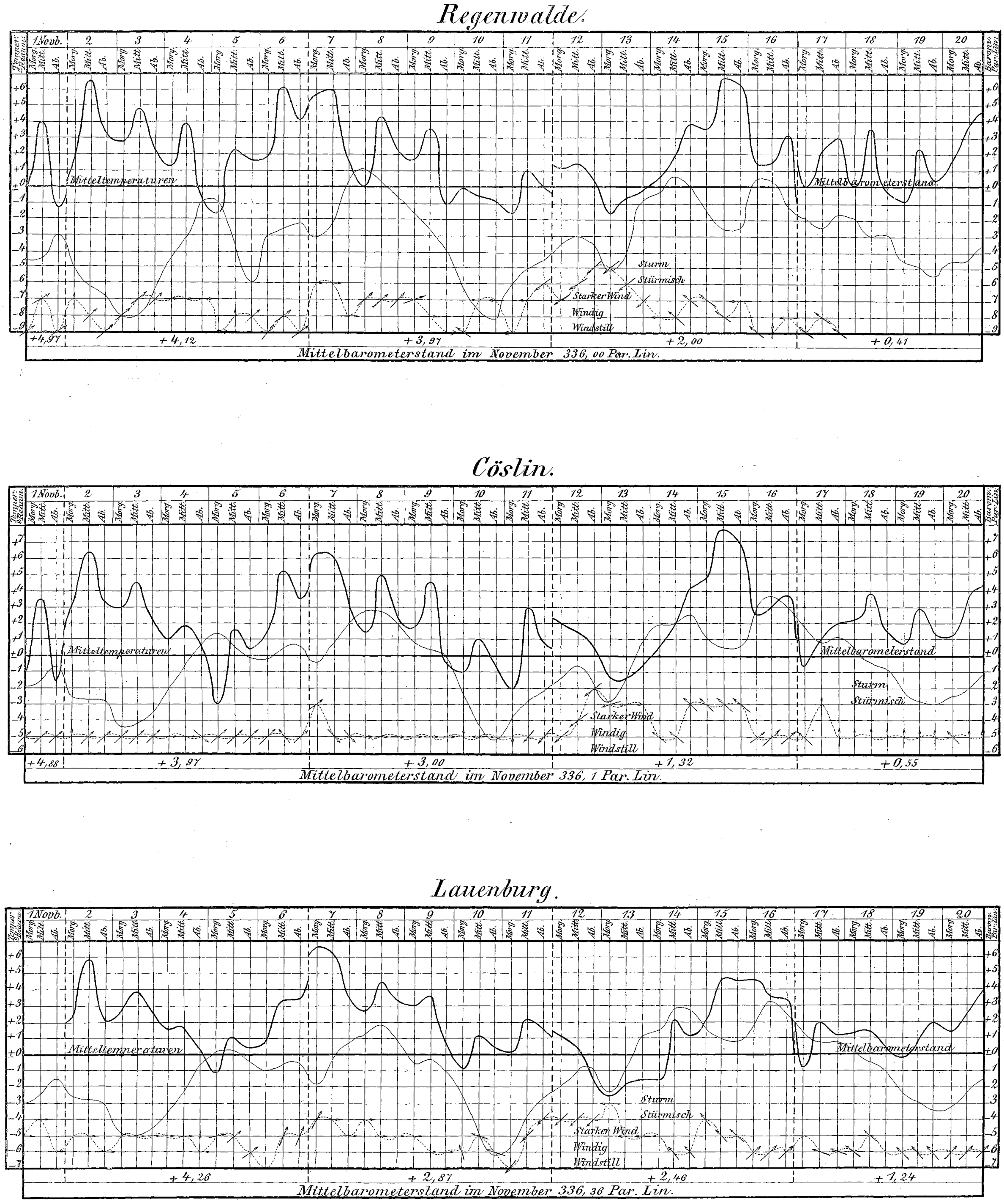

Figure 7: Storm surge of November 12th–13th, 1872, at the Baltic Sea, Graphical Representation of the Meteorological Tables, Table 1, Table 2, Table 3.

These individual profile representations show on the ordinates the deviations from the mean temperature (left) and barometer readings (right) in the observation intervals. The numbers of the deviations from the mean reduced in the tables are plotted with + or − upwards or downwards and these fixed points of the observations are connected with each other by a coherent curve.

The curves drawn in fine line are those of the deviations of the air pressure; those marked in strong line are the deviations of the temperature. For the sake of simplicity, exactly the same zero point is shown for both, i.e. the mean barometer reading and mean temperatures refer to only one abscissa axis; furthermore, for the ordinates for the barometer, 1 Paris line is assumed to be equal to 1 degree Réaumur for the thermometer. Since five-day mean temperatures were used, the curves of the deviation of the temperature at the respective days had to be set off according to the stepwise decrease of the mean temperature from 5 to 5 days. This is easily evident in the graphic representations at the transition points. In this way only, the relation between the temperature and the air pressure could be visualized.

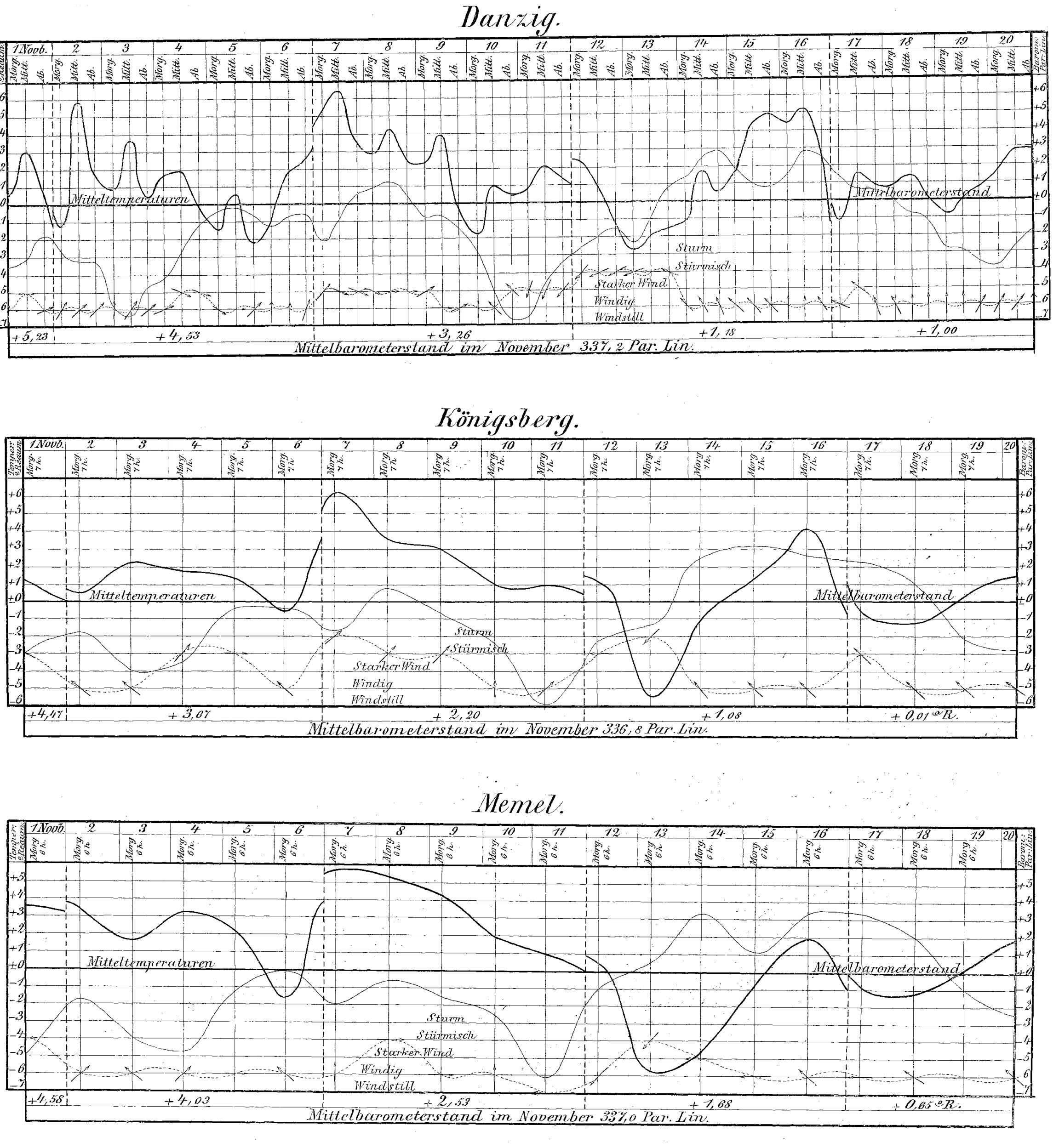

Figure 8: Storm surge of November 12th–13th, 1872, at the Baltic Sea, Graphical Representation of the Meteorological Tables, Table 1, Table 2, Table 3.

The wind directions are printed by small arrows at the ordinates, which adapt to the normal orientation of the graph, i.e. north-up orientation (Figure 5 to Figure 8). The wind intensity

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in the five gradations is represented again by a curve in a broken line, where the five lowest horizontals of the profiles are used for the intensity level, so that in calm conditions the abscissa axis coincides with the curve.

Furthermore, these profiles have been put together in Figure 9 and Figure 10 as an aerial picture: namely the wind movement for itself and next to it the deviations from the mean air pressure as well as from the mean temperatures have been compiled.

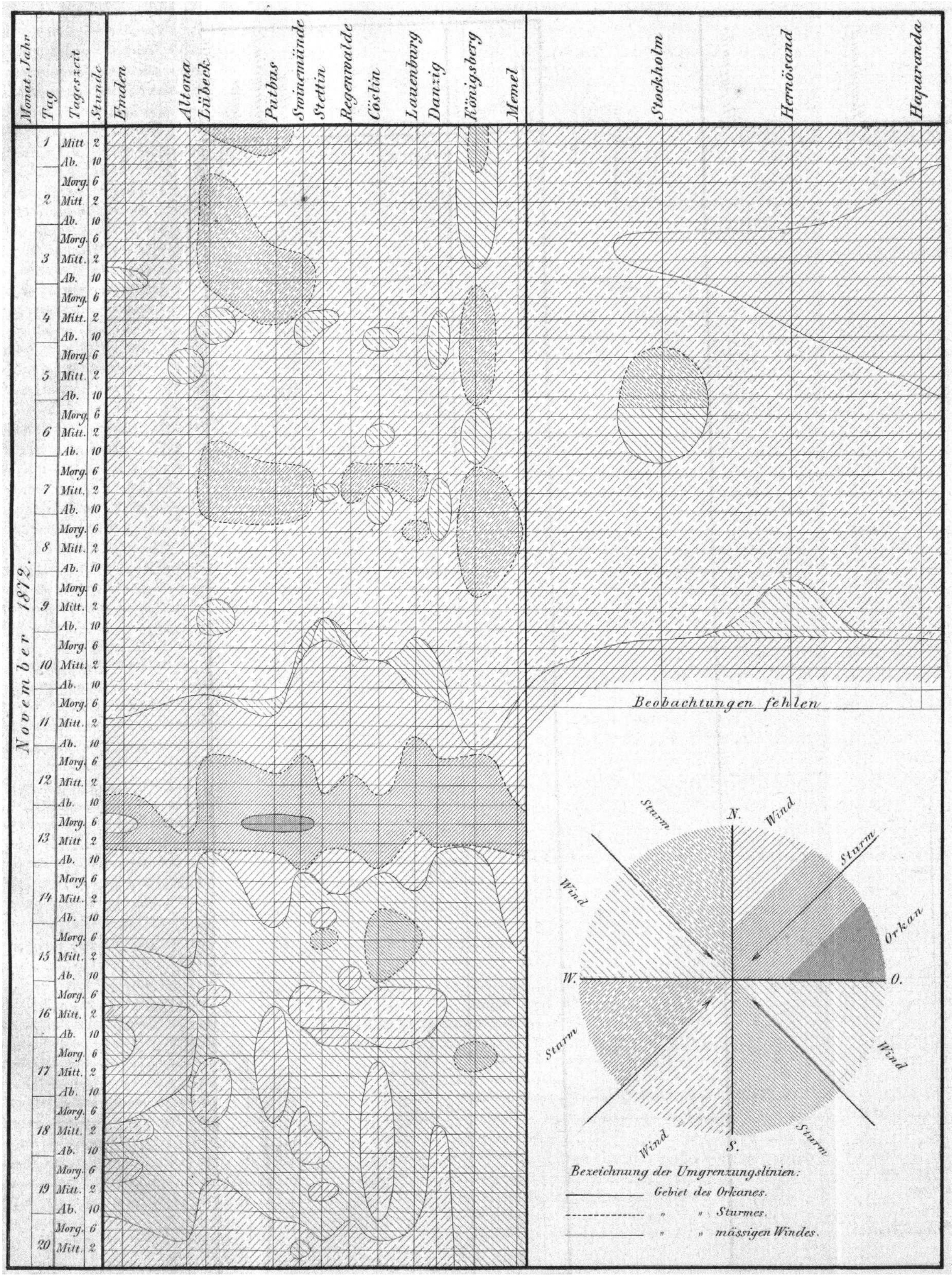

Figure 9: Graphical Representation of the Wind Movement at the Meteorological Stations near the Coasts of the Baltic Sea.

 https://doi.org/10.18171/1.092107

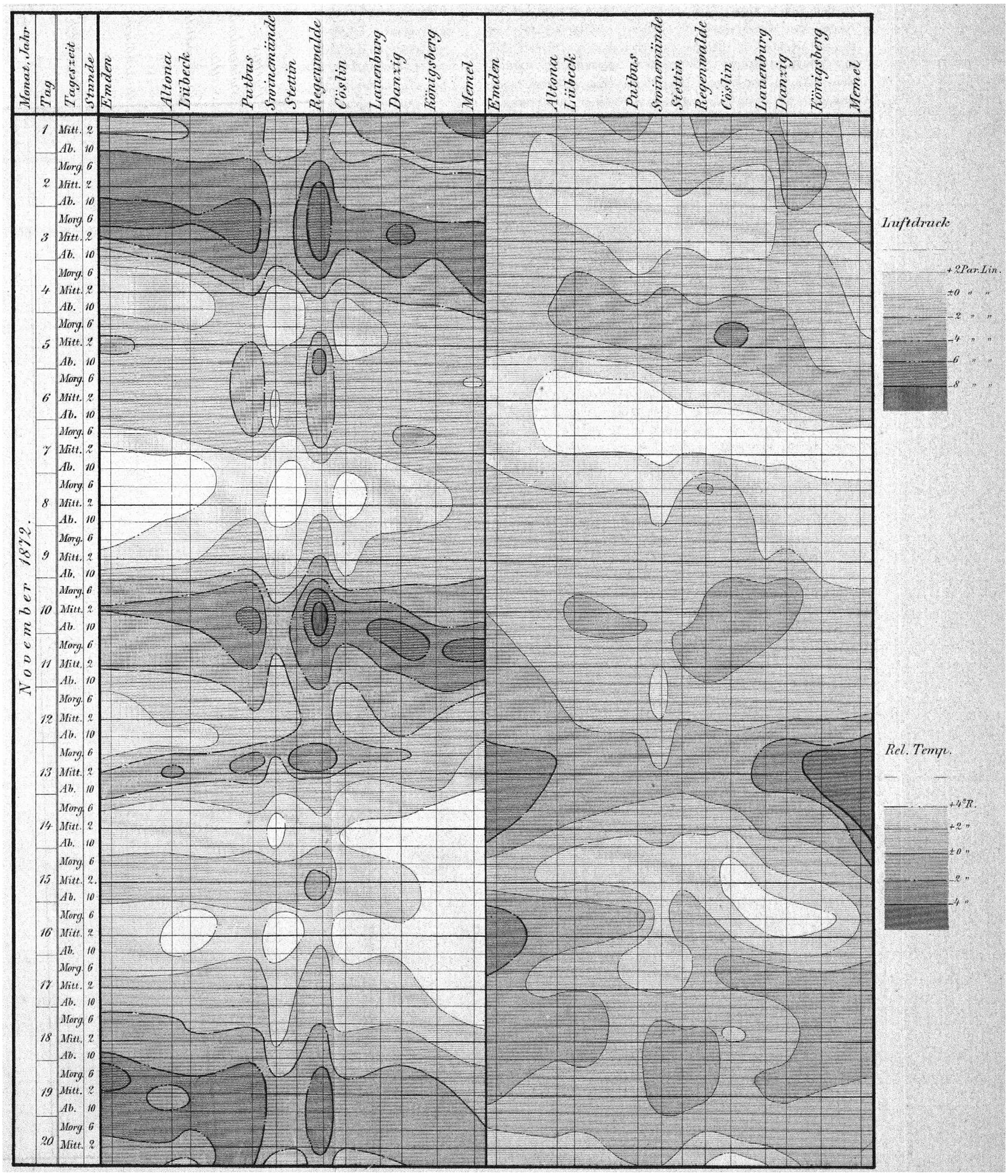

Figure 10: Graphical Representation of the Relative Air Pressure and the Relative Temperature at the Meteorological Stations near the Prussian Baltic Sea Coasts.

The stations are indicated from left to right, the times from top to bottom, whereby the geographical position of the stations in relation to their distance from each other is taken into account.

In the overall representation of the wind movement, the four quadrants have been treated separately for the wind direction, as shown by the different hatching of the areas, whereby all westerly winds have been hatched in broken lines, all easterly winds in continuous lines. All winds of the southwest quadrant have been designated SW, all winds of the northwest quadrant NW etc., so that the intermediate variations within the quadrant have not been transferred to the surface image, in order not to make this unclear.

In each wind direction the higher or lower intensities are kept apart by keeping the hatching only darker or lighter while maintaining the characteristics. Since the wind directions as well as the wind forces often extend at several places over the same and longer time, the similar winds are delimited by lines which mark the existence of this wind direction according to time and place.

The overall representation of the barometer and temperature reading is given in such a way that those areas which show the same barometer or thermometer readings according to time and location are delimited by lines and are made darker where these readings were low and lighter where they were higher. These lines, taken from the profiles, are delimited for the barometer reading by 2 to 2 Parisian lines, for the thermometer by 2 to 2 degrees Réaumur. Also in these bounded areas the degree of extent is characterized by broken lines.

In order to obtain as correct a picture as possible in the graphic representation of the temperature, i.e. uninfluenced by the effects of the sun, only those ordinates of the individual representations have been used which correspond to the morning observations. Imagine the extreme points of this ordinate connected by a curve and this curve projected onto the plane.

Compared to the earlier atmospheric presentation covering Northern and Central Europe, this surface image now shows only the zone where the actual battle between Polar and Equatorial Current took place, and it characterizes even more sharply that constant barometric minimum between Putbus and Regenwalde, which runs uniformly through the entire observation period and also appears in the thermometer readings, however less pronounced.

The strong Equatorial Current from November 1st in the evening to November 3rd in the evening, progressing in time from West to East, is expressed in the low barometer readings and simultaneous higher temperatures. The light attacks of the Polar Current on November 4th are still rejected by the Equatorial Current on November 5th and 6th, as indicated by the falling of the barometer and rising of the thermometer, but then it begins with greater force. From November 6th to November 10th, the northwesterly winds appear now and then at the height of Gdansk (Danzig), Coeslin (Cöslin), Szczecin (Stettin) and Lübeck, the barometer rises as a result of the advancing cold air, which, however, cannot take on speed since its path is blocked by the Equatorial Current; however, the thermometer begins to fall constantly due to the cold air. Thus, November 10th approaches and with it a northeasterly wind with decreasing temperature, but also, quite abnormally, with falling barometer. The latter abnormality clearly indicates that the cold air came to dominate only in a thin layer over the Baltic Sea area while the Equatorial Current continued to dominate in full strength in the upper air layers. On November 12th, in the lower layers, as a result of the ever-increasing rejection of the Equatorial Current, the northeasterly. wind became more and more active. The lateral flow of cold air on the northwestern side of the Equatorial Current made the latter come to the fore again, and as a result of this it jumped back in the night of November 12th-13th, did not allow itself to be broken by the Polar Current, but diverted the latter's path to the east. The restriction of the profile of the Polar Current at its border with the Equatorial Current between Regenwalde and Kiel, the unchanged position of the local barometric minimum at the height of Putbus, increased the former to a hurricane. It took possession of the Baltic Sea area, was pushed through the east to the southeast with increasing temperature, and finally had to give up the field completely to the

Equatorial Current on November 19th and 20th. The Equatorial Current had thus claimed the battlefield and the intense attack of the Polar Current was beaten off under the outbreak of an eminent hurricane.

Figure 9 and Figure 10 thus give an overview of the local battle over the Baltic Sea area, without making known the acting forces at their sources, while in the earlier the whole appearance is shown on the whole European terrain. It is clear from this that tracing the symptoms on the instruments at the Baltic stations along the line of the incipient battle by no means gives a sufficient overview since comparing the deviations from the mean barometer and thermometer readings is of little help in foreseeing the coming events. Rather an examination of the absolute values of the air pressure and the temperature in wide areas is necessary in order to get a full picture of the battlefield and of the opponents, and thus to have a correct basis for a forecast.

4 Tidal Movements in the Baltic Sea during the Storm Surge of November 12th–13th, 1872

4.1 The Actual Conditions of Water Levels, Currents and Salinity of the Baltic Sea

4.1.1 Water levels

The hitherto discussed phenomena in the area of the atmosphere, which the storm surge showed in its wake, will now be assessed in their effects on the water surface, and in doing so, it will be necessary to first give some information about the available material and its use. The material used here is taken throughout from the observations made at the tide gauging stations by pilot or harbour officials. The latter refer to the absolute water levels read at the gauges, the direction of the current, the direction of the wind, the strength of the same, and some weather notes. Furthermore, notes on salinity and specific gravity of the Baltic Sea water are taken from the detailed memorandum of the Schleswig government, edited by the former building inspector Bargum, for this part.

The observation area in the Baltic Sea extends from Aarösund to Memel, the time of the observations used from November 6th to November 20th, 1872, since the phenomena from November 6th to November 9th are of such importance and also of decisive weight in the occurrence of the storm surge.

The zero points of the tide gauges are located at quite different heights and since the height of the tide gauges in relation to each other has not yet been officially determined by all of them, all absolute water levels read at the tide gauges had to be reduced to the level of the mean water of the Baltic Sea in order to bring them into relation to each other. The average water levels of the stations were taken as the level, whereby the gauge stations in the province of Schleswig-Holstein, which have only been established in recent years, have the shortest time period for determining the same. As far as possible, a comparison of these mean water levels with the levellings made by the Office of Land Triangulation on the Baltic Sea coast in connection with some sea gauges has shown that the mean water levels observed at the gauges can be regarded without substantial error as coinciding with the level of the Baltic Sea, for illumination of the storm surge, in that errors of up to about 1 decimetre at the most may have occurred, an error limit which, in the case of such a significant water change as occurred here, does not in any case significantly cloud the picture to be created.

It is more questionable whether the water levels on the coast are in harmony with those in the open sea, since all the observations are only on the coast. However, also in this respect, great differences are not assumed; rather it may be assumed that the water changes in the open sea will move in similar lines with those on the beach. Comparisons made in this respect between two tide gauges, one at Thiessow on Mönchgut, the other on the east side of the island of Greifswalder Oie, 2 miles out to sea, have not revealed any differences of particular value, and it only requires a comparison of the profiles of the water levels between Thiessow and Greifswalder Oie given in Figure 14 to confirm this. Unfortunately, the gauge on Greifswalder Oie was knocked away from the sea in the evening of November 13th, making further observation impossible.

The reduced water levels or the fluctuation of the absolute water levels observed at the gauges by the height of the mean water level, as well as the wind directions observed at the same times and places - according to the 16-part wind rose and the intensity of the wind in 5 gradations - as in the I. section - are compiled from the stations evident from the head of the diagram in Table 4 to Table 8.

On the basis of these tables, graphical profile representations of the water level and the wind intensity of the individual stations have been drawn on Figure 11, Figure 12, Figure 13, Figure 14 and Figure 15, the representation of which will be clear to every technician even without further explanation. The distance of the horizontal lines from each other is 0.5 metres for the water level and means at the same time a unit for the wind intensity. The wind direction is again expressed by arrows with north-up orientation. These profiles, which will have their special interest for the individual stations, are not particularly considered here, but only served as a basis for an overall picture of the wind movement and the water change over the whole area from Aaroe to Memel, on which the connection between the different stations is easier to see at a glance. By connecting the profile points found from the observations, which the above-mentioned tables prove, by means of uniform curves, the possibility arose to interpolate all times not observed and thus to gain the material for the overall overviews of the graphical representations in Figure 16.

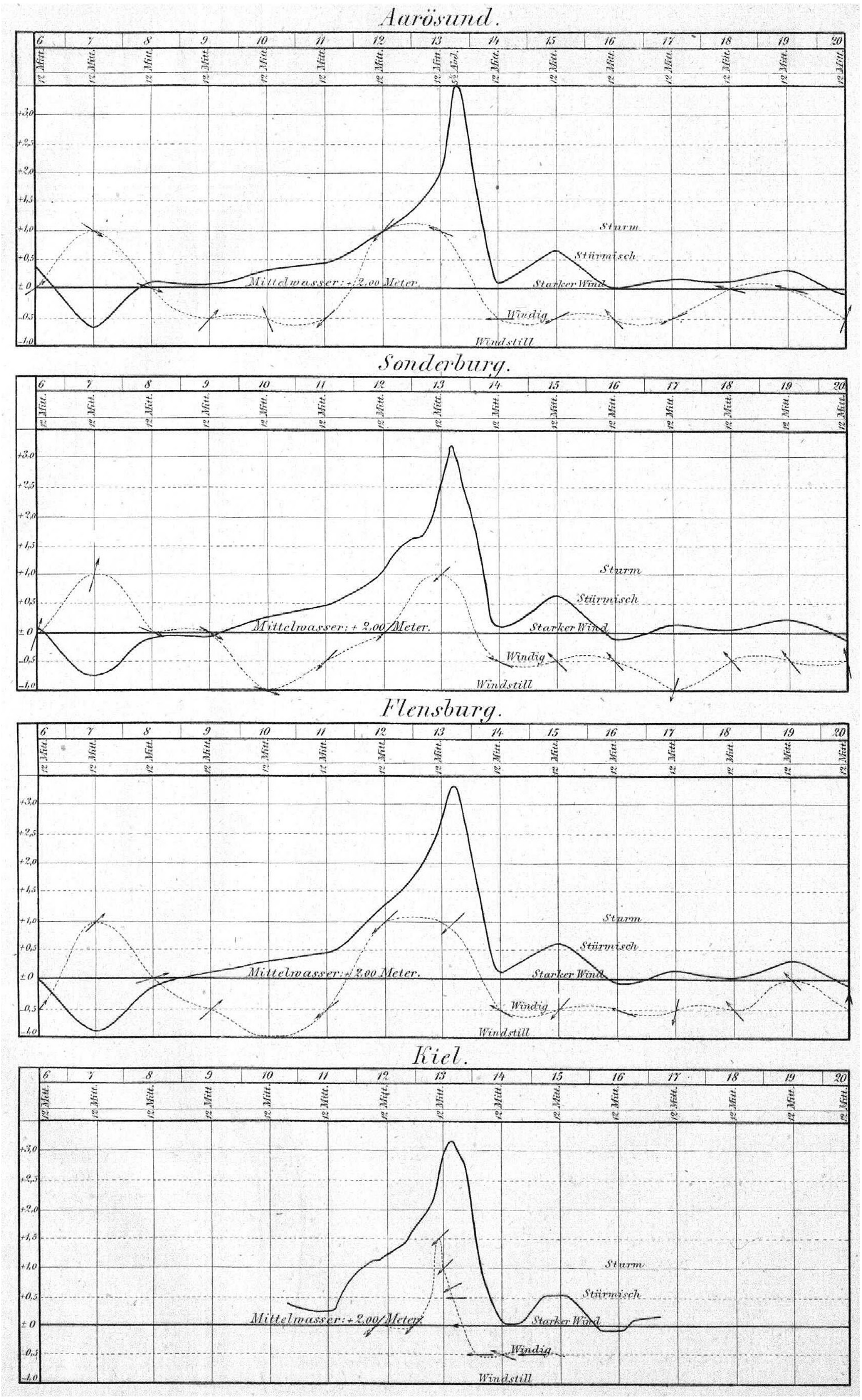

Figure 11: Graphical Representation of the Water Level and Wind Intensity in the Individual Stations (Aarösund to Kiel).

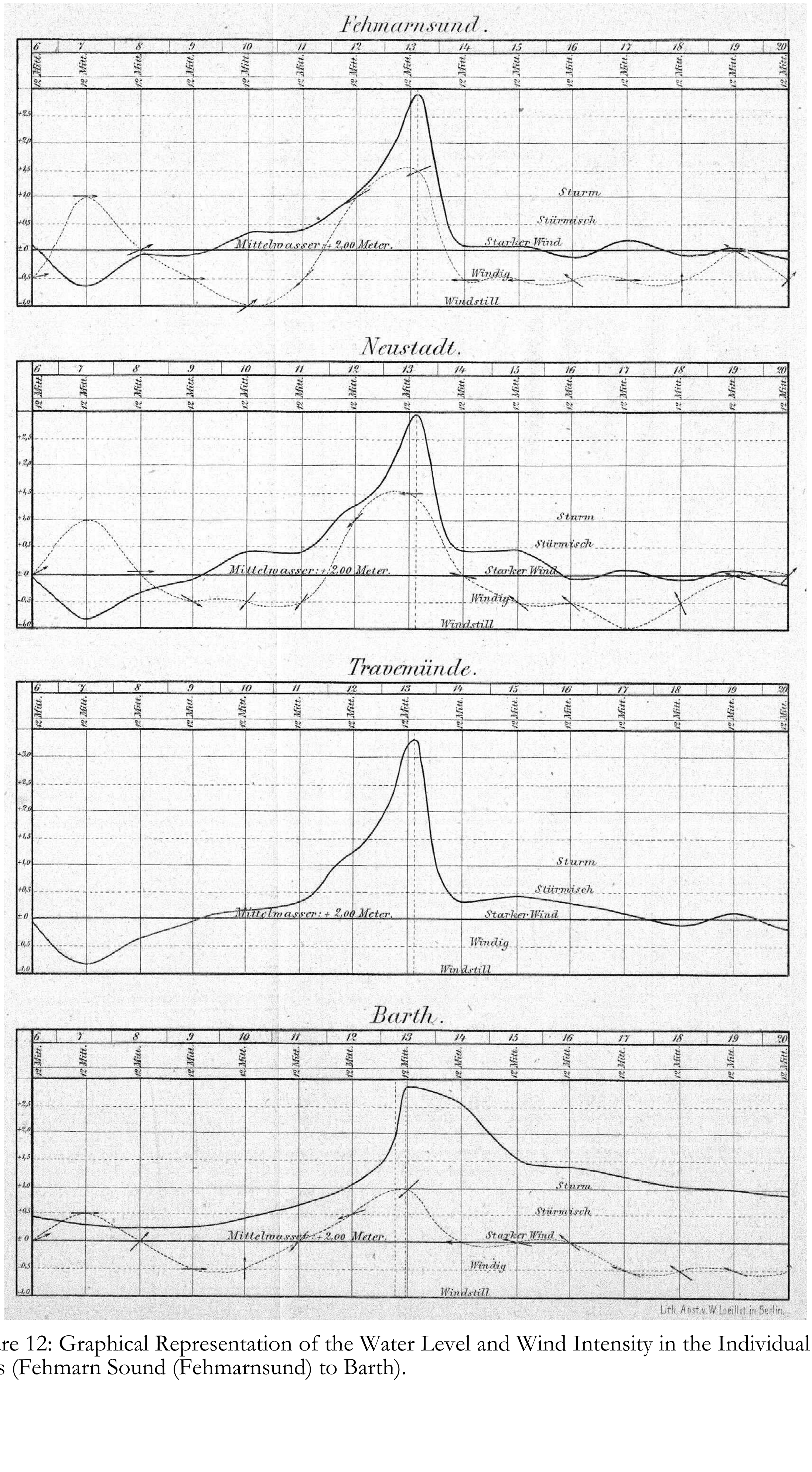

Figure 12: Graphical Representation of the Water Level and Wind Intensity in the Individual Stations (Fehmarn Sound (Fehmarnsund) to Barth).

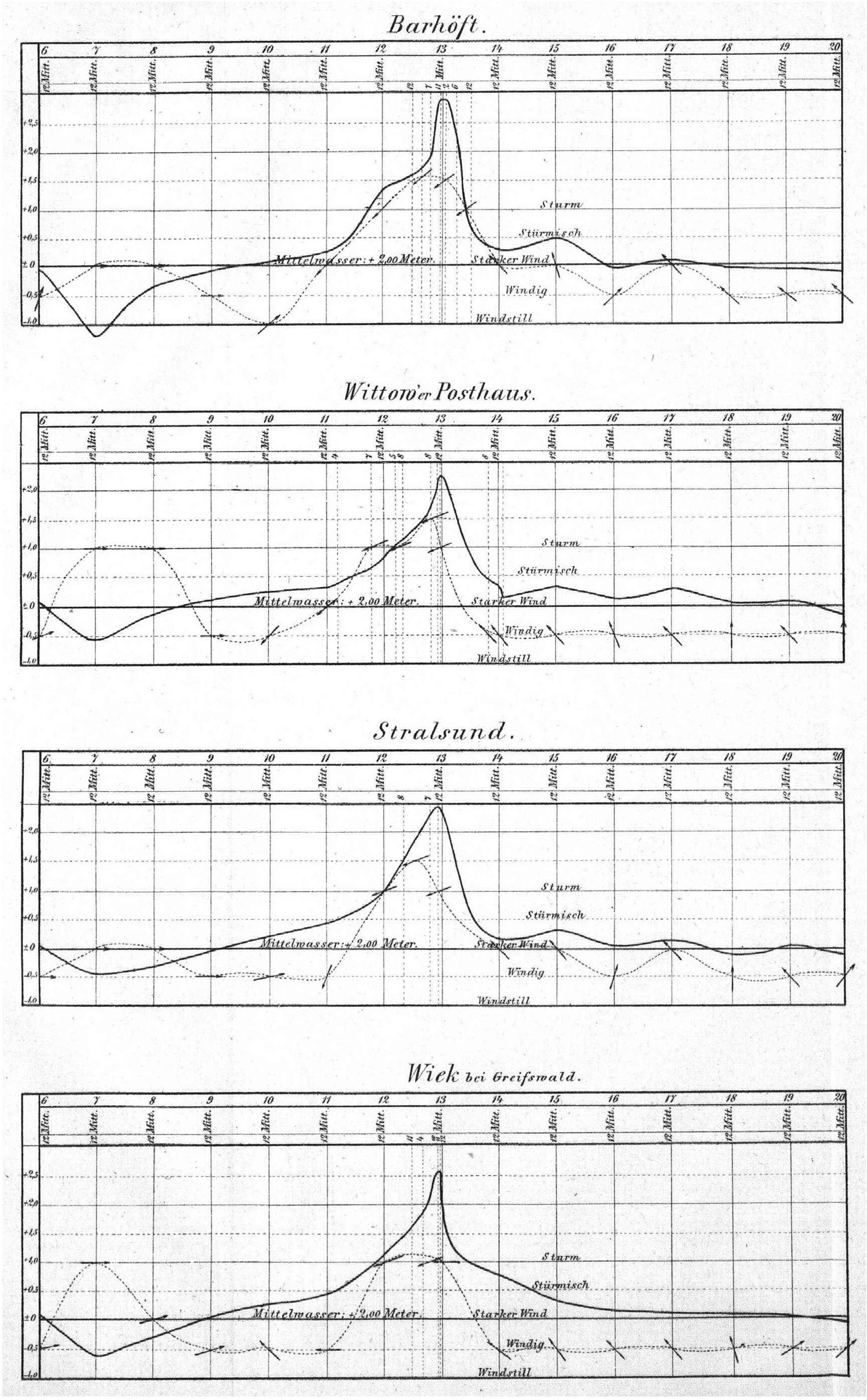

Figure 13: Graphical Representation of the Water Level and Wind Intensity in the Individual Stations Barhöft to Wiek).

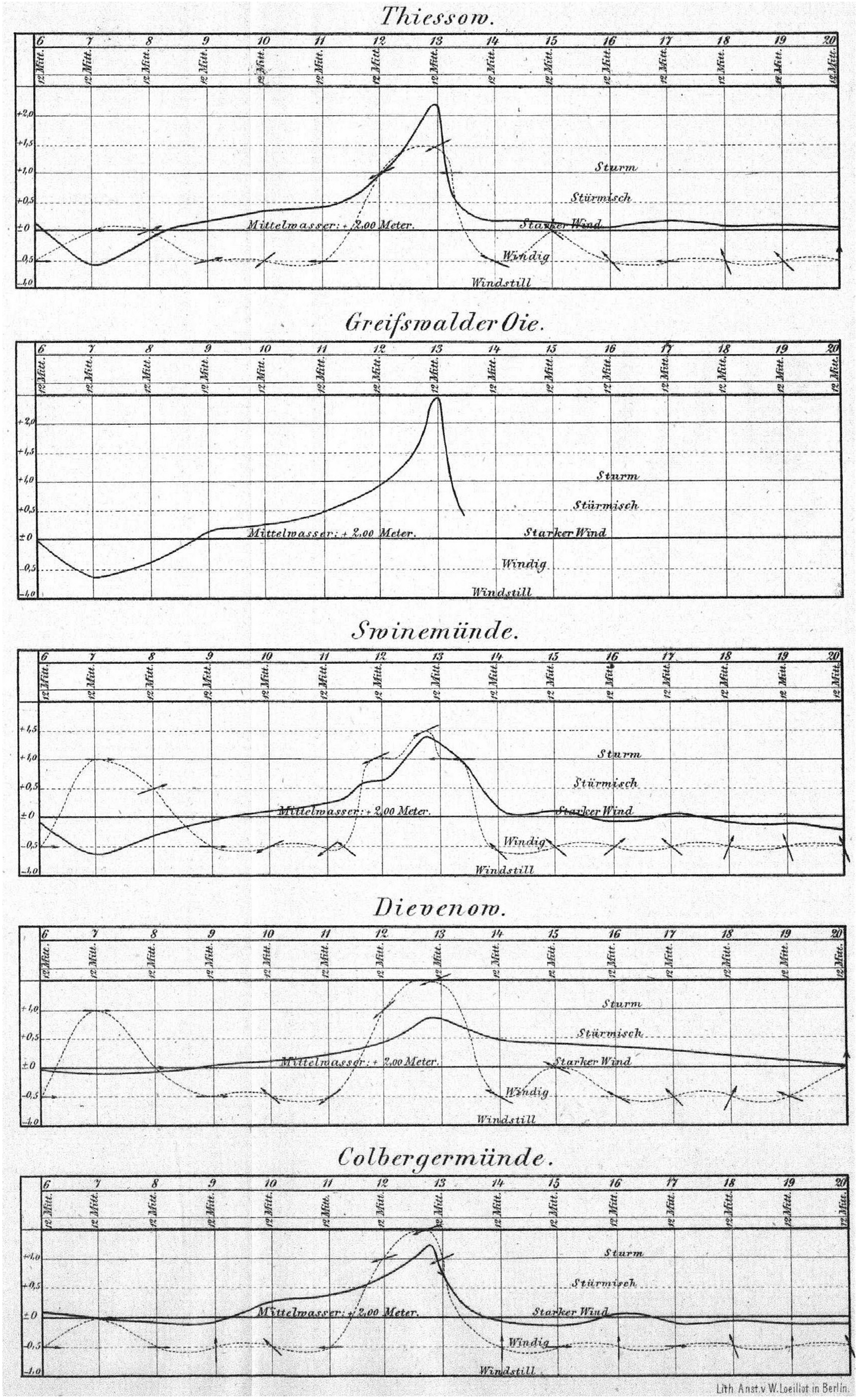

Figure 14: Graphical Representation of the Water Level and Wind Intensity in the Individual Stations (Thiessow to Colbergermuende (Colbergermünde)).

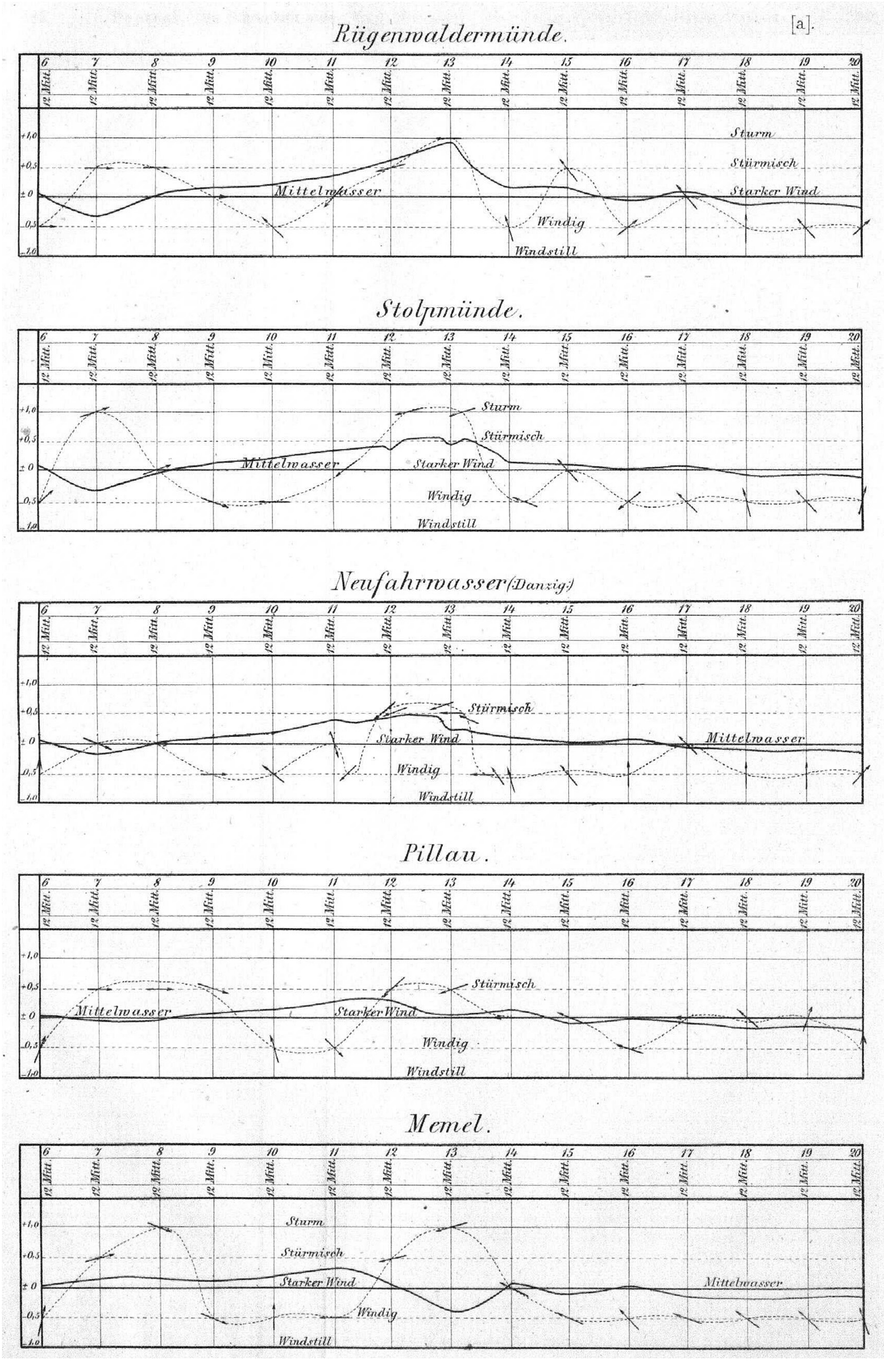

Figure 15: Graphical Representation of Water and Wind movement on the Meteorological Stations near the Baltic Sea.

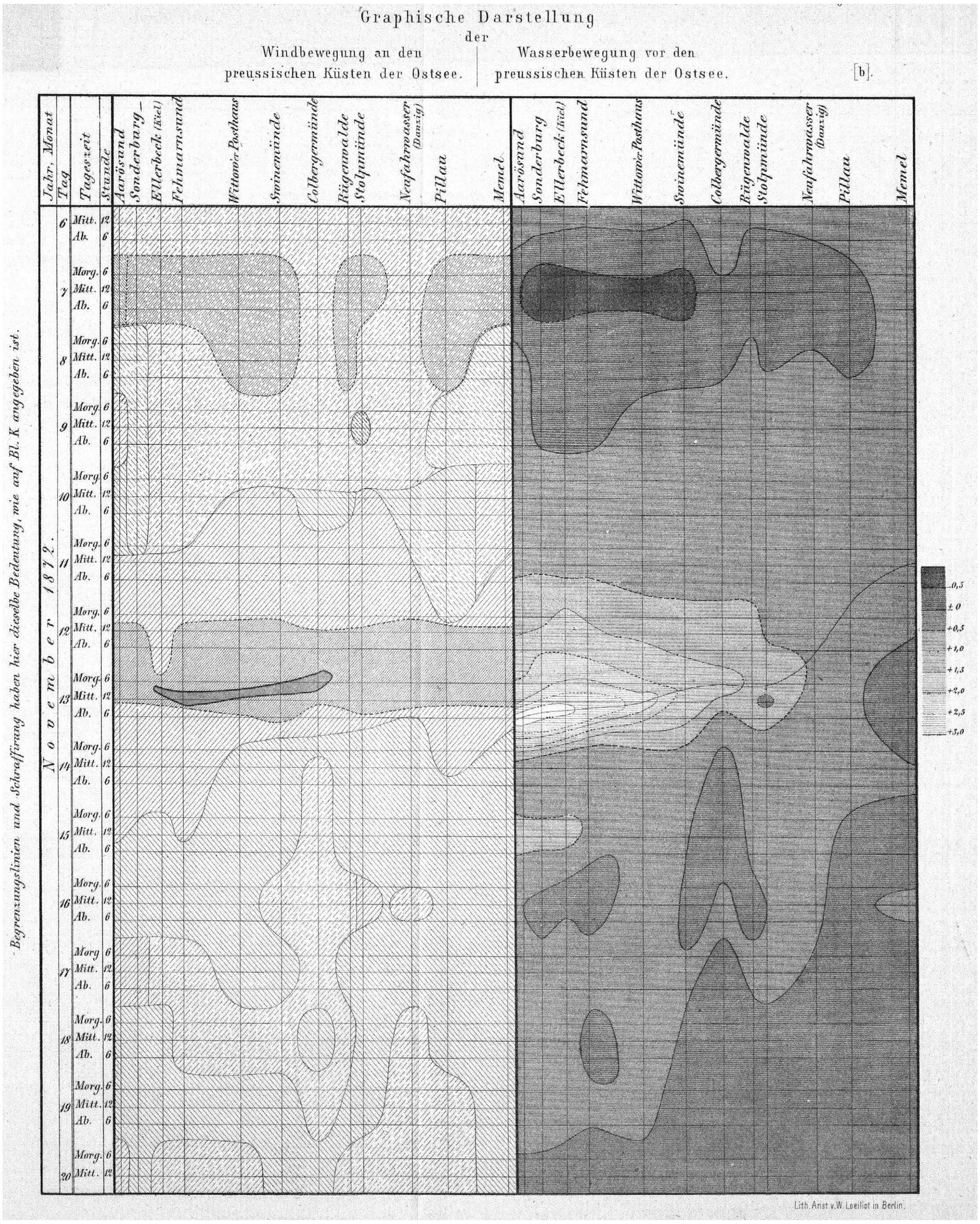

Figure 16: Graphical Representation of Wind and Water Level Movement along the Prussian Baltic Sea Coasts.

From these individual profiles, the two surface images in Figure 16 on the wind and water movement in the period from November 6th to November 20th inclusive have been obtained by marking the height of the water level above or below mean water at the relevant times of the various stations and drawing their horizontal curves, which belong to the same water level height in increments of 0.6 metre each. In this way, the fluctuation of the level of the Baltic Sea at the beach stretches of the observation stations over the whole area from the Prussian-Danish to the Prussian-Russian border can be surveyed at a glance. To facilitate this overview, the lowest water levels are shaded dark, while the highest water levels are kept light.

	Höchster Wasserstand Meter	am 13. November Nachmittag
Schleimünde	3,44	3 h 30′
Rabelsund	3,44	4 h
Kappeln	3,30	4 h 45′
Arnis	3,12	5 h 15′

In the same way, in Figure 16, the direction and the intensity of the wind have been marked for the relevant times of the selected stations, although, for the sake of clarity, the winds have been marked only according to their 4 quadrants. In order to emphasize the intensity, the same is delimited according to the observation areas and now the difference of the two main movements is characterized by a hatching, namely for the west side of the wind rose in torn, for the east side of the wind rose in sharply drawn hatching, which still emphasizes the greater or lesser intensity by a denser, respectively further hatching.

Subsequent to Figure 16, if one follows the time, above all the storm from the west side of the wind rose, lasting 24 or 48 hours, respectively, between November 6th–7th at noon and until the morning of November 9th, is shown. Since this storm became of great importance for the development of the storm surge, it may be noted right here in relation to the size of its area that this westerly storm, according to the reports of v. Boguslawski, extended from the Scottish coasts over the North Sea, over Schleswig-Holstein and over the large basin of the Baltic Sea. As for the processes of this storm, according to the graphic representation in Figure 10, it already occurred once at Lübeck on the morning of November 2nd, moved along the Baltic Sea, and marked Koenigsberg (Königsberg) on the morning of November 4th. The general wind direction from November 1st to 10th or even 11th respectively was from the southwestern quadrant.

The fateful northeast was first signalled on November 10th at noon from the Wittow post house to Stolp, then on November 11th at noon to Nowy Port (Neufahrwasser) and Memel, and finally on the morning of November 12th also in Pillau, i.e. in the whole extension of the observation area. At noon on November 12th, the NE wind, which in the meantime had become stronger and stronger, appeared as a gale on the whole line, except at Ellerbeck; the increase in strength was thus simultaneous up to the Holstein coast. The hurricane, on the other hand, which began shortly after midnight between November 12th and 13th in Colberg, rose like an island out of the storm sea, gradually spreading across the area, and disappeared again between Ellerbeck and Sønderborg (Sonderburg) on the morning of November 13th, continuing in Fehmarn Sound (Fehmarnsund) until the afternoon.

The decrease of the storm to strong or moderate winds, respectively occurs again almost at the same time on November 13th in the afternoon on the whole line, in Swinoujscie (Swinemünde) continuing in strength until about 8 p.m.. The boundary between the normally occurring wind shifts from the NE quadrant into the SE quadrant forms a very irregular line with respect to time. First one meets the SE in Nowy Port (new fairway), namely in the evening of November 13th, then evenly progressing along the coast until the morning of November 14th in the Wittower post house, then also in the afternoon of November 15th gaining terrain to the east and finally in the evening of November 15th on the whole observation line as the sole dominator of the area.

During the period from November 14th to 20th, southwestern quadrant winds reappeared intermittently to give way alternately to SE until the SE wind had regained possession almost all along the line in the Baltic area from November 18th to 20th.

The graphical representation of the water movement in the Baltic Sea before, during and after the storm surge, compared with the wind movement, provides an easy overview of the correlation, although it should not be forgotten that the observation material on the water levels was collected more often during the day only in the period from November 11th to 14th, while before and after this period it was recorded only at noon according to the existing regulations, so that for these latter periods the intermediate elements in the observation are missing.

The comparison shows in the first row the effect of the westerly storm prevailing from November 7th to 8th inclusively. It can be seen that the water level, which had reached the mean water level on the evening of November 6th, dropped rapidly and significantly on the whole line from Aarösund to behind Pillau under the influence of the southwesterly storm. In particular, the large basin of the western and southernmost part of the Baltic Sea was affected, which must have been the most vulnerable to the attack as well as to its situation. From Aarösund to Swinoujscie (Swinemünde), the water fell by more than 0.5 metres below the mean water level. At noon on November 8th, however, the water began to rise again, namely in Aarösund due to the close connection with the Kattegat, and on the eastern wing of the observation line from Rögenwalde to the mean water level. In the evening of November 9th, this level was also reached in Sønderborg (Sonderburg), Ellerbeck and Fehmarn Sound (Fehmarnsund). The water continued to rise steadily, and especially in the western part of the Baltic Sea from November 9th onwards faster than in the remaining part, which can be seen in the approach of the horizontal, i.e. in the shortening of the times, in Figure 16.

In order to be able to follow the movement of the storm surge even more specifically, two longitudinal profiles of the Baltic Sea from Aarösund to Memel are attached in Figure 1, in which the rise and fall of the water is shown according to the various more important time periods, whereby the mean water level lying in the gradient is assumed to be horizontal at 0. The boundary between the low water level of the Baltic Sea in the western basin and the higher water level in the northern basin is shown at the level of Pillau, i.e. at the location where the water level swings to the NE. Also, the water levels of the whole following tide show that the neutral line, around which the level of the lake fluctuates, is maintained without significant deviations at the level of Pillau, and in the orientation plan Figure 4 this neutral boundary is entered in a broken line.

From the evening of November 9th until 6 p.m. in the afternoon of November 11th, the water at Aarösund, which had been rising since November 7th, was raised to a height of 0.5 metres above mean water; the same height was not reached until midnight at Rügenwalde, while at Stolpmünde it was not until the afternoon of November 12th, while at Nowy Port (Neufahrwasser) this height was not reached at all.

The rise of the tide up to the height of 0.5 metres above mean water thus occurred from west to east, and the water level in this first period, under the influence of the steady northeasterly wind, forms a fairly evenly inclined surface rising toward Holstein.

Following the further rise of the tide, then according to Figure 16 the equal water level line +1.0 metres shows that this level was first reached at Ellerbeck, namely in the night from November 11th to 12th within about 12 hours, while the same water level at Aaroe occurred 6 hours later at noon on November 12th. The progress of the tidal wave was thus significantly delayed between Alsen and the Danish islands.

Table 4: Meanwater Level at Aerosund, Sønderborg (Sonderburg), Flensburg, Ellerbeck, Fehmarn Sound (Fehmarnsund) and Neustadt

Tabelle IV.

Gebiet			Ostsee																	
Pegel-Stationen			**Aaroesund.**			**Sonderburg.**			**Flensburg.**			**Ellerbeck.**			**Fehmarnsund.**			**Neustadt.**		
Mittelwasser			+ 2,00 m			+ 1,88 m			+ 2,00 m			+ 0,006 m			+ 1,97 m			+ 2,05 m		
Tage im Novbr.	Stunde	Tageszeit	Abweich. vom Mittelwasser	Windrichtung	Windstärke	Abweich. vom Mittelwasser	Windrichtung	Windstärke	Abweich. vom Mittelwasser	Windrichtung	Windstärke	Abweich. vom Mittelwasser	Windrichtung	Windstärke	Abweich. vom Mittelwasser	Windrichtung	Windstärke	Abweich. vom Mittelwasser	Windrichtung	Windstärke
6	12	Mitt.	+ 0,36	SW	2	+ 0,10	WSW	2	± 0,00	SW	1	....	SW	....	+ 0,03	WSW	1	— 0,03	WSW	2
7	12	Mitt.	— 0,64	WNW	4	— 0,74	WSW	4	— 0,84	SW	4	....	SW	....	— 0,67	W	4	— 0,85	W	4
8	12	Mitt.	+ 0,10	WNW	2	— 0,06	WNW	2	— 0,14	WSW	2	....	SW	....	— 0,07	WSW	2	— 0,29	W	2
9	12	Mitt.	+ 0,08	SW	1	— 0,04	WNW	2	+ 0,06	SW	1	....	SW	....	— 0,05	W	1	— 0,01	NW	1
10	12	Mitt.	+ 0,32	SSO	1	+ 0,26	WNW	0	+ 0,30	SW	0	....	SSW	....	+ 0,33	SW	0	+ 0,41	NO	1
11	12	Mitt.	+ 0,46	NO	1	+ 0,44	NO	1	+ 0,48	NO	1	....	NO	....	+ 0,41	NO	1	+ 0,39	NO	1
	4	Nachmitt.																		
	8	Abd.																		
12	6	Morg.	....	....	....	....	....	....	....	....	....	+ 1,15	NO	2						
	7	Morg.																		
	12	Mitt.	+ 1,00	NO	4	+ 1,08	NO	2	+ 1,30	NO	4	+ 1,26	NO	2	+ 1,05	NO	4	+ 1,25	NO	4
	3	Nachmitt.	....	....	....	....	....	....	....	....	....	+ 1,33	NO	2						
	4	Nachmitt.	....	....	....	+ 1,32														
	5	Nachmitt.																		
	6	Abd.	....	....	....	+ 1,52	....	....	....	....	....	+ 1,44	NO	2						
	8	Abd.	....	....	....	+ 1,62														
	12	Nachts	....	....	....	....	....	....	....	....	....	+ 1,73	—	2						
13	4	Morg.	....	....	....	+ 1,62														
	6	Morg.	....	....	....	....	....	....	....	....	....	+ 2,01	NO	3						
	7	Morg.	....	....	....	....	....	....	....	....	....	+ 2,15	NO	3						
	8	Morg.	....	....	....	+ 1,90	....	....	....	....	....	+ 2,33	NO	3						
	9	Morg.	....	....	....	....	....	....	....	....	....	+ 2,51	NO	3—5						
	10	Morg.	....	....	....	....	....	....	....	....	....	+ 2,72	NO	4						
	11	Mitt.	....	....	....	....	....	....	....	....	....	+ 2,88	NO	4						
	12	Mitt.	+ 2,00	OSO	4	+ 2,59	NO	4	....	....	....	+ 2,98	NO	3						
	2	Nachmitt.	....	....	....	....	....	....	....	....	....	+ 3,14	ONO	3						
	2½	Nachmitt.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	+ 2,95	O	5
	3	Nachmitt.	....	....	....	....	....	....	....	....	....	+ 3,17	O	3	+ 2,89	ONO	5			
	3½	Nachmitt.	....	....	....	....	....	....	....	....	....	+ 3,17	O	2						
	4	Nachmitt.	....	....	....	+ 3,10	....	....	....	....	....	+ 3,09	O	2						
	4½	Nachmitt.	....	....	....	+ 3,20	....	....	+ 3,31	NO	4									
	5	Nachmitt.	....	....	....	....	....	....	....	....	....	+ 3,06	O	2						
	5½	Nachmitt.	+ 3,50																	
	6	Abd.	....	....	....	....	....	....	....	....	....	+ 2,98	O	2						
	8	Abd.	....	....	....	+ 2,72	....	....	....	....	....	+ 2,80	O	2						
	12	Nachts	....	....	....	+ 2,20	....	....	....	....	....	+ 1,99	O	1						
14	4	Morg.	....	....	....	....	....	....	....	....	....	+ 1,05	O	1						
	8	Morg.																		
	12	Mitt.	+ 0,12	O	1	+ 0,13	OSO	1	+ 0,16	OSO	1	+ 0,16	OSO	1	+ 0,05	O	1	+ 0,41	OSO	5
	2	Nachmitt.																		
	4	Nachmitt.																		
	6	Abd.	....	....	....	....	....	....	....	....	....	+ 0,11	O	1						
15	12	Mitt.	+ 0,68	ONO	1	+ 0,58	SO	1	+ 0,66	NO	1	....	O	....	+ 0,07	O	1	+ 0,45	SO	1
16	12	Mitt.	± 0,00	SO	1	— 0,10	SO	1	— 0,04	OSO	1	....	SO	....	— 0,17	SO	1	— 0,07	SO	1
17	12	Mitt.	+ 0,10	ONO	1	+ 0,16	NNO	0	+ 0,14	NNO	1	....	W	....	+ 0,19	W	1	+ 0,11	—	0
18	12	Mitt.	+ 0,08	OSO	2	+ 0,03	SO	1	+ 0,02	SO	1	....	OSO	....	— 0,03	S	1	— 0,07	SSO	1
19	12	Mitt.	+ 0,30	OSO	2	+ 0,21	SO	1	+ 0,30	SO	2	....	SO	....	+ 0,01	SO	2	+ 0,11	OSO	2
20	12	Mitt.	— 0,06	SSW	1	— 0,16	SSO	1	— 0,12	S	1	....	WSW	....	— 0,19	SW	1	— 0,19	SW	2

Table 5: Meanwater Level at Travemuende (Travemünde), Barth, Barhöft, Wittower Post House, Stralsund and Wiek next to Greifswald

Tabelle V.

Gebiet			Ostsee																	
Pegel-Stationen			**Travemünde.**			**Barth.**			**Barhöft.**			**Wittower Posthaus.**			**Stralsund.**			**Wiek** bei Greifswald.		
Mittelwasser			+ 5,20 m			+ 1,25 m			+ 1,18 m			+ 1,18 m			+ 1,18 m			+ 1,26 m		
Tage im Novbr.	Stunde	Tages-zeit	Abweich. vom Mittelwasser	Wind-richtung	Wind-stärke	Abweich. vom Mittelwasser	Wind-richtung	Wind-stärke	Abweich. vom Mittelwasser	Wind-richtung	Wind-stärke	Abweich. vom Mittelwasser	Wind-richtung	Wind-stärke	Abweich. vom Mittelwasser	Wind-richtung	Wind-stärke	Abweich. vom Mittelwasser	Wind-richtung	Wind-stärke
6	12	Mitt.	— 0,05	WSW	....	+ 0,40	WSW	2	— 0,06	SSW	1	+ 0,04	WSW	1	+ 0,02	W	1	+ 0,05	WSW	1
7	12	Mitt.	— 0,85	W	....	+ 0,29	W	3	— 1,18	W	2	— 0,53	W	4	— 0,42	W	2	— 0,63	W	4
8	12	Mitt.	— 0,30	WSW	....	+ 0,24	SW	2	— 0,32	W	2	— 0,14	W	4	— 0,34	W	2	— 0,27	WSW	2
9	12	Mitt.	— 0,05	WSW	....	+ 0,24	W	1	— 0,04	W	1	+ 0,07	W	1	— 0,04	W	1	+ 0,04	WSW	1
10	12	Mitt.	+ 0,15	SW	....	+ 0,40	S	1	+ 0,12	SW	0	+ 0,25	NO	1	+ 0,20	WSW	1	+ 0,31	SO	1
11	12	Mitt.	+ 0,30	O	....	+ 0,63	NO	2	+ 0,28	NO	2	+ 0,31	NO	2	+ 0,40	NNO	1	+ 0,44	O	1
	4	Nachmitt.	....	....	....	....	....	....	....	....	....	+ 0,39								
	8	Abd.																		
12	6	Morg.																		
	7	Morg.	....	....	....	....	....	....	....	....	....	+ 0,63	ONO	4						
	12	Mitt.	+ 1,25	ONO	....	+ 1,05	ONO	3	+ 1,32	NO	4	+ 0,78	ONO	4	....	ONO	4	+ 0,18	ONO	4
	3	Nachmitt.																		
	4	Nachmitt.																		
	5	Nachmitt.	....	....		....	....	....	....	....	....	+ 1,02	ONO	4						
	6	Abd.																		
	8	Abd.	....	....		....	....	....	....	....	....	....	....		+ 1,51					
	12	Nachts	....	....		....	....	....	+ 1,62	NO	5	....	....		....	ONO	5	11h + 1,62	ONO	4
13	4	Morg.	....	....	Windstärke nicht angegeben	....	....	....	....	....	....	....	....		....	....	....	+ 1,88	ONO	4
	6	Morg.													7h 20m					
	7	Morg.	....	....		+ 1,89	....	....	+ 1,94	NO	5	....	....	....	+ 2,35					
	8	Morg.	....	....		....	....	....	....	....	....	+ 1,65	ONO	5						
	9	Morg.													10h 30m			+ 2,64	ONO	4
	10	Morg.	....	....		....	....	....	....	....	....	+ 2,12	ONO	5	+ 2,46	....	....	+ 2,64	ONO	4
	11	Mitt.	....	....		+ 2,83	NO	4	+ 2,92	NO	5	+ 2,27	ONO	4		ONO	4			
	12	Mitt.	....	....		....	....	....	....	....	....	....	....	....	....	....	....	+ 1,88	O	4
	2	Nachmitt.	+ 3,32	NO		....	....	....	+ 2,92	NO	5									
	2½	Nachmitt.																		
	3	Nachmitt.																		
	3½	Nachmitt.																		
	4	Nachmitt.																		
	4½	Nachmitt.																		
	5	Nachmitt.																		
	5½	Nachmitt.																		
	6	Abd.	....	....	....	....	....	....	+ 1,32	NO	5									
	8	Abd.																		
	12	Nachts	....	....	....	....	....	....	+ 0,72	NO	5									
14	4	Morg.																		
	8	Morg.	....	....	....	....	....	....	....	....	....	+ 0,47	SO	1						
	12	Mitt.	+ 0,35	OSO	....	+ 2,55	O	2	+ 0,31	SO	2	+ 0,33	SO	1	+ 0,16	SO	2	+ 0,78	SO	1
	2	Nachmitt.	....	....	....	....	....	....	....	....	....	+ 0,18	SO	1						
	4	Nachmitt.																		
	6	Abd.																		
15	12	Mitt.	+ 0,45	OSO	....	+ 1,55	OSO	2	+ 0,54	SSO	2	+ 0,33	SO	1	+ 0,36	SO	2	+ 0,31	SO	1
16	12	Mitt.	+ 0,30	OSO	....	+ 1,39	SO	2	+ 0,02	SW	1	+ 0,07	SSO	1	+ 0,02	SSW	1	+ 0,16	SO	1
17	12	Mitt.	+ 0,12	NW	....	+ 1,25	OSO	1	+ 0,10	SO	2	+ 0,31	SO	1	+ 0,18	SO	2	+ 0,15	SO	1
18	12	Mitt.	— 0,15	SSO	....	+ 1,10	80	1	+ 0,02	SO	1	+ 0,02	S	1	— 0,10	S	1	+ 0,13	SSO	1
19	12	Mitt.	+ 0,10	SO	....	+ 1,03	OSO	1	— 0,06	SO	1	+ 0,07	SO	1	+ 0,02	SO	1	+ 0,05	SW	1
20	12	Mitt.	— 0,20	WSW	....	+ 0,95	S	1	— 0,11	SO	1	— 0,14	S	1	— 0,08	SW	1	— 0,16	SW	1

Table 6: Meanwater Level at Thiessow, Swinoujscie (Swinemünde), Dievenow, Colbergermuende (Colbergermünde) and Ruegenwaldermuende (Rügenwaldermünde)

Tabelle VI.

Gebiet			Ostsee															
Pegel-Stationen			**Thiessow.**			**Swinemünde.**			**Dievenow.**			**Colbergermünde.**			**Rügenwaldermünde.**			
Mittelwasser			+ 1,26 m			+ 7,06 m			+ 2,04 m			+ 1,52 m			+ 1,09 m			
Tag im Novbr.	Stunde	Tageszeit	Abweich. vom Mittelwasser	Windrichtung	Windstärke	Abweich. vom Mittelwasser	Windrichtung	Windstärke	Abweich. vom Mittelwasser	Windrichtung	Windstärke	Abweich. vom Mittelwasser	Windrichtung	Windstärke	Abweich. vom Mittelwasser	Windrichtung	Windstärke	
6	12	Mitt.	+0,15	W	1	−0,05	W	1	−0,02	W	1	+0,10	W	1	+0,06	W	1	
7	12	Mitt.	−0,55	W	2	−0,63	W	4	−0,16	W	4	±0,00	W	2	−0,30	W	3	
8	12	Mitt.	−0,11	WSW	2	−0,26	WSW	3	−0,06	W	2	−0,08	W	1	+0,06	W	3	
9	12	Mitt.	+0,21	WSW	1	−0,03	W	1	+0,02	W	1	−0,06	S	1	+0,17	W	2	
10	12	Mitt.	+0,36	NO	1	+0,10	ONO	1	+0,06	SO	1	+0,28	SO	1	+0,24	SO	1	
11	12	Mitt.	+0,47	O	1	+0,26	NO	1	+0,24	NO	1	+0,36	O	1	+0,37	NO	2	
	4	Nachmitt.																
	8	Abd.	....	....	....	+0,31	SO	1										
12	6	Morg.																
	7	Morg.	....	....	....	+0,63	ONO	4										
	12	Mitt.	+0,99	ONO	4	+0,65	ONO	4	+0,44	NO	4	+0,68	ONO	4	+0,61	ONO	3	
	3	Nachmitt.																
	4	Nachmitt.																
	5	Nachmitt.	....	....	....	....	....	....	....	....	....	+0,83						
	6	Abd.																
	8	Abd.	....	....	....	+0,94	ONO	4										
	12	Nachts	....	....	....	....	....	....	....	....	....	....	ONO	5				
13	4	Morg.																
	6	Morg.																
	7	Morg.	....	....	....	+1,41	ONO	5	....	....	....	+1,23						
	8	Morg.																
	9	Morg.	+2,19	ONO	5	....	....	....	....	....	....	....	ONO	5				
	10	Morg.																
	11	Mitt.																
	12	Mitt.	+2,19	ONO	5	+1,26	O	4	+0,84	ONO	5	+0,83	ONO	4	+0,95	O	4	
	2	Nachmitt.																
	2½	Nachmitt.																
	3	Nachmitt.																
	3½	Nachmitt.																
	4	Nachmitt.																
	4½	Nachmitt.																
	5	Nachmitt.																
	5½	Nachmitt.																
	6	Abd.	+0,62	O	4													
	8	Abd.	....	....	....	+1,04	O	4										
	12	Nachts																
		Morg.																
	8	Morg.	....	....	....	+0,42	OSO	1										
	12	Mitt.	+0,21	OSO	1	+0,21	SO	1	+0,48	OSO	1	−0,03	S	1	+0,17	SSO	1	
	2	Nachmitt.																
	4	Nachmitt.																
	6	Abd.	....	....		+0,02	OSO	1										
15	12	Mitt.	+0,21	SO	2	+0,10	SO	1	+0,40	OSO	2	−0,19	W	1	+0,17	SO	3	
16	12	Mitt.	+0,07	SO	1	−0,05	SW	1	+0,34	OSO	1	+0,05	S	1	−0,02	SW	1	
17	12	Mitt.	+0,23	O	1	+0,02	SO	1	+0,26	SO	1	−0,11	W	1	+0,06	SO	2	
18	12	Mitt.	+0,07	SSO	1	−0,13	SSW	1	+0,20	SSW	1	−0,03	SSO	1	−0,10	S	1	
19	12	Mitt.	+0,07	SO	1	−0,13	SSO	1	+0,08	OSO	1	−0,13	S	1	−0,07	SO	1	
20	12	Mitt.	±0,00	S	1	−0,24	SSO	1	±0,00	S	2	−0,16	SSO	1	−0,15	SW	1	

Table 7: Meanwater Level at Stolpmünde, Nowy Port (Neufahrwasser), Pillau, Memel, Wolgast and Auelam.

Tabelle VII.

Gebiet			Ostsee												Peene					
Pegel-Stationen			**Stolpmünde.**			**Neufahrwasser** bei Danzig.			**Pillau.**			**Memel.**			**Wolgast.**			**Anclam.**		
Mittelwasser			+ 0,71 m			+ 3,53 m			+ 2,41 m			+ 0,47 m			+ 1,26 m			+ 2,04 m		
Tage im Novbr.	Stunde	Tageszeit	Abweich. vom Mittelwasser	Windrichtung	Windstärke	Abweich. vom Mittelwasser	Windrichtung	Windstärke	Abweich. vom Mittelwasser	Windrichtung	Windstärke	Abweich. vom Mittelwasser	Windrichtung	Windstärke	Abweich. vom Mittelwasser	Windrichtung	Windstärke	Abweich. vom Mittelwasser	Windrichtung	Windstärke
6	12	Mitt.	+ 0,05	SW	1	+ 0,05	S	1	+ 0,03	SSW	1	+ 0,05	SSO	1	— 0,02	WSW	1	— 0,05	SW	1
7	12	Mitt.	— 0,30	WSW	4	— 0,13	WNW	2	— 0,03	W	3	+ 0,16	WSW	3	— 0,31	W	2	± 0,00	W	1
8	12	Mitt.	— 0,03	WSW	2	+ 0,03	W	2	— 0,01	W	3	+ 0,16	WNW	4	— 0,18	SW	1	— 0,34	W	1
9	12	Mitt.	+ 0,15	WNW	1	+ 0,13	W	1	+ 0,07	WNW	3	+ 0,10	WNW	1	— 0,05	W	1	— 0,31	W	1
10	12	Mitt.	+ 0,23	O	1	+ 0,19	SO	1	+ 0,15	SSO	1	+ 0,19	S	1	+ 0,04	W	1	+ 0,03	NW	1
11	12	Mitt.	+ 0,36	....	....	+ 0,39	NNW	2	+ 0,31	NW	1	+ 0,32	O	1	+ 0,33	NO	1	+ 0,24	NO	1
	4	Nachmitt.	....	NO	2		NO	1												
	8	Abn.	....	....	....	+ 0,37														
12	6	Morg.	....	....	....	+ 0,41														
	7	Morg.	+ 0,41	....	....	....	NO	3												
	12	Mitt.	+ 0,36	....	....	+ 0,45	ONO	3	+ 0,29	NO	3	+ 0,03	ONO	3	....	NO	4	+ 0,52	O	4
	3	Nachmitt.																		
	4	Nachmitt.																		
	5	Nachmitt.	+ 0,52	ONO	4	....	ONO	3	....	....	....	....	....	....	+ 0,55					
	6	Abd.	....	....	....	+ 0,49														
	8	Abd.																		
	12	Nachts	....	....	....	....	ONO	3												
13	4	Morg.																		
	6	Morg.	....	....	....	+ 0,47	....	....	....	....	....	....	....	....	+ 1,56					
	7	Morg.	+ 0,55	....	....	....	ONO	3												
	8	Morg.																		
	9	Morg.	....	....	....	....	....	....	....	....	....	....	....	....	+ 1,67					
	10	Morg.	....	....	....	....	....	....	....	....	....	....	....	....	+ 1,77					
	11	Mitt.																		
	12	Mitt.	+ 0,47	....	....	+ 0,23	O	3	+ 0,03	ONO	3	— 0,42	ONO	4	+ 1,69	NO	4	+ 1,13	O	4
	2	Nachmitt.	....	....	....	....	....	....	....	....	....	....	....	....	+ 1,56					
	2½	Nachmitt.																		
	3	Nachmitt.																		
	3½	Nachmitt.																		
	4	Nachmitt.	....	....	....	....	....	....	....	....	....	....	....	....	+ 1,25					
	4½	Nachmitt.	....	ONO	4															
	5	Nachmitt.	+ 0,55	....	....	....	OSO	3												
	5½	Nachmitt.																		
	6	Abd.	....	....	....	+ 0,23	....	....	....	....	....	....	....	....	+ 0,75					
	8	Abd.																		
	12	Nachts	....	....	....	....	O	1												
14	4	Morg.	....	....	....	+ 0,15														
	8	Morg.	+ 0,31				SO	1												
	12	Mitt.	+ 0,15	....	....	+ 0,13	SSO	1	+ 0,17	O	2	+ 0,03	OSO	2	+ 0,66	ONO	1	+ 0,84	OSO	1
	2	Nachmitt.																		
	4	Nachmitt.	....	OSO	1	....	SSO	1												
	6	Abd.	+ 0,15	....	....	+ 0,07														
15	12	Mitt.	+ 0,10	SO	2	+ 0,03	SO	1	— 0,03	OSO	2	— 0,10	OSO	1	+ 0,52	OSO	1	+ 0,71	OSO	1
16	12	Mitt.	± 0,00	NO	1	+ 0,05	S	1	— 0,01	OSO	1	+ 0,03	SO	1	+ 0,35	SO	1	+ 0,58	SO	1
17	12	Mitt.	+ 0,02	SO	1	— 0,07	SO	2	— 0,09	O	2	— 0,13	OSO	1	+ 0,27	S	1	+ 0,47	SO	1
18	12	Mitt.	— 0,08	SSO	1	— 0,15	S	1	— 0,17	SO	2	— 0,15	SO	1	+ 0,21	SO	1	+ 0,37	S	1
19	12	Mitt.	— 0,08	SO	1	— 0,13	S	1	— 0,15	SSW	2	— 0,15	SO	1	+ 0,17	SO	1	+ 0,29	OSO	1
20	12	Mitt.	— 0,13	SSW	1	— 0,19	SW	1	— 0,19	S	1	— 0,13	SSO	1	+ 0,08	S	1	+ 0,18	S	1

Table 8: Meanwater Level at Lebbin, Wollin, Stepenitz and Szczecin (Stettin).

Tabelle VIII.

Gebiet			Swine			Dievenow			Haff			Oder		
Pegel-Stationen			**Lebbin.**			**Wollin.**			**Stepenitz.**			**Stettin.**		
Mittelwasser			+ 0,99 m			+ 1,96 m			+ 0,78 m			+ 0,47 m		
Tage im Novbr.	Stunde	Tages-zeit	Abweich. vom Mittelwasser	Wind-richtung	Wind-stärke	Abweich. vom Mittelwasser	Wind-richtung	Wind-stärke	Abweich. vom Mittelwasser	Wind-richtung	Wind-stärke	Abweich. vom Mittelwasser	Wind-richtung	Wind-stärke
6	12	Mitt.	— 0,11	W	1	— 0,12	W	0	— 0,07	NW	1	+ 0,03	W	1
7	12	Mitt.	— 0,13	W	2	— 0,08	W	2	— 0,04	W	1	+ 0,05	WNW	2
8	12	Mitt.	— 0,21	W	2	— 0,16	W	2	— 0,08	W	1	— 0,08	SW	1
9	12	Mitt.	— 0,17	W	2	— 0,18	W	1	— 0,05	SO	1	— 0,06	W	1
10	12	Mitt.	— 0,05	O	0	— 0,12	O	1	+ 0,13	O	1	+ 0,03	O	1
11	12 4 8	Mitt. Nachmitt. Abd.	+ 0,11	N	1	+ 0,06	N	1	+ 0,29	NO	1	+ 0,22	SO	1
12	6 7 12 3 4 5 6 8 12	Morg. Morg. Mitt. Nachmitt. Nachmitt. Nachmitt. Abd. Abd. Nachts	+ 0,27	NO	1	+ 0,14	NO	4	+ 0,50	NO	2	+ 0,42	NO	2
13	4 6 7 8 9 10 11 12 2 2½ 3 3½ 4 4½ 5 5½ 6 8 12	Morg. Morg. Morg. Morg. Morg. Morg. Mitt. Mitt. Nachmitt. Nachmitt. Nachmitt. Nachmitt. Nachmitt. Nachmitt. Nachmitt. Nachmitt. Abd. Abd. Nachts	+ 0,43	NNO	4	+ 0,26	O	4	+ 0,50	NO	4	+ 0,60	O	4
14	4 8 12 2 4 6	Morg. Morg. Mitt. Nachmitt. Nachmitt. Abd.	+ 0,65	O	1	+ 0,58	O	1	+ 0,66	NW	1	+ 0,76	O	1
15	12	Mitt.	+ 0,53	O	1	+ 0,42	SO	4	+ 0,53	O	1	+ 0,60	OSO	1
16	12	Mitt.	+ 0,43	O	1	+ 0,40	S	0	+ 0,45	O	1	+ 0,55	O	1
17	12	Mitt.	+ 0,35	O	1	+ 0,26	SO	1	+ 0,31	SO	1	+ 0,39	SO	1
18	12	Mitt.	+ 0,23	O	1	+ 0,22	SSW	1	+ 0,25	SO	1	+ 0,33	SSO	1
19	12	Mitt.	+ 0,13	O	1	+ 0,06	OSO	1	+ 0,13	S	1	+ 0,21	SO	1
20	12	Mitt.	+ 0,05	S	1	+ 0,02	S	1	+ 0,05	SO	1	+ 0,16	SW	1

The same level, however, was only reached to the east on November 13th at 6 a.m. between Colbergermuende (Colbergermünde) and Rügenwalde, at a time when the rise of the north-east tower at the height of Colberg was already becoming a hurricane. At midnight on November 12th–13th the level of the sea was shaped in a fairly uniform slope according to Figure 1 from Memel to Ellerbeck and the delay of the progress of the tide only remained noticeable up to Aaroe.

From this point, which shows a water level height corresponding to the ordinary high tides, the conditions change in a striking way, but according to the hurricane-like occurrence of the storm marked by the pilot stations. This hurricane, first signalled in Colbergermuende (Colbergermünde), progressed from Colbergermuende (Colbergermünde) to Ellerbeck from about 2 a.m. until 7 a.m., driving the Baltic Sea level, which had already risen to high tide, in front of it in a mighty wave. At 6 a.m. in the morning of November 13th, this wave grows with its crest, Figure 1, lying near Fehmarn Sound (Fehmarnsund). The narrowness of Fehmarn Sound (Fehmarnsund) is a hindrance to its progress, but the pressure is so enormous that the level of the water surface at noon on November 13th (Figure 1) sinks between Rügenwalde and Swinoujscie (Swinemünde), whereas the upwelling water mass rises almost 1 metre in 6 hours from Swinoujscie (Swinemünde) to Ellerbeck, and although the gale subsides at noon along the entire coastline, this wave still rises to a height of 1.5" from Ellerbeck to Aaroesund in 5½ hours.

Here it is to be emphasized in particular, how the rise of the tide, namely west of Swinoujscie (Swinemünde), was clearly proportionate to the wind intensity and how even after cessation of the hurricane the enormous tidal wave continues to propagate at a constant rate and only peters out when hitting the surrounding mainland after the Little Belt. In Figure 16 the crests of the highest local water level line are connected by a sharply drawn line, the course of which characterizes the contemporary local maximum water level on the whole coastline. In Figure 1, on the other hand, the profile lines of the observation times from 12 noon to 5:30 p.m. of November 13th indicate to what extent the lake level was driven under the pressure of the hurricane. The maximum of the crest was 3.17 metres above sea level (a.s.l.) at Ellerbeck at 3:20 p.m. On the way of this wave up the Little Belt into that wedge-shaped narrowing strait and finding its termination against solid land, its crest is still lifted by 0.5 metres.

During the entire course of the storm surge in the western part of the Baltic Sea, the neutral boundary line at the high point of Pillau, which station shows only a slight change of water, is conspicuously prominent, and when the stations further to the NNE located stations are missing in the observation circle, already the single station Memel suggests that during this whole phenomenon low water levels existed in the northern basin of the Baltic Sea, especially since the further station at Windau in Curland with a water level of 4 feet on November 11th at 1 p.m., also on November 13th at 5 p.m. marks the minimum water level with 1 foot 4 inches. No relationship to the mean water level could be given there.

From the building inspector Bargum a compilation of the wind speeds with the water levels is given, which was formed from the observations at Ellerbeck. According to this, those relations took place which can be taken from the table on p. 189/190 above.

If in these periods the highest wind speed occurred in the morning at 10 a.m. and the highest water level at 3:40 p.m., while the wind speed decreased from 30.7 metres to 16.8 metres, it follows that the elevation of the water level in this period was no longer the result of a strong wind pressure, but the consequence of a progressing crest of a tidal wave moving from east to west, as can be seen in Figure 1, which found its origin in the area of the Baltic Sea between Colberg and Wittower Post House.

A similar progress of the wave results in the Schlei, which cuts into the land like a river up to 5.5 miles. The movement of the flood crest gives the following record for November 13th:

	Höchster Wasserstand Meter	am 13. November Nachmittag
Schleimünde	3,44	$3^{h}\ 30'$
Rabelsund	3,44	4^{h}
Kappeln	3,30	$4^{h}\ 45'$
Arnis	3,1[illegible]	$5^{h}\ 15'$

	Höchster Wasserstand Meter	am 13. November Nachmittag
Nifs	3,03	$6^{h}\ 30'$
Missunde	3,05	$7^{h}\ 45'$
Haddeby	3,24	$9^{h}\ 15'$
Gottorf	3,34	$9^{h}\ 30'$

Datum	Stunden von	Stunden bis	Windgeschwindigkeit pro Secunde Meter	Richtung des Windes	Ansteigung des Wassers pro Stunde Centimeter	
12. November	Morgens 6 Uhr	Mittags 12 Uhr	von 6,9 bis 13,7	NO.	1,83	
	Mittags 12 Uhr	Abends 6 Uhr	13,7	NO. zu O.	3	
12. zum 13. November	Abends 6 Uhr	Morgens 6 Uhr	13,7 bis 19,4	NO. bis NO. zu O.	4,75	
13. November	Morgens 6 Uhr	Morgens 9 Uhr	19,4	NO. zu O. bis NO.	16,6	Windgeschwindigkeit in Cuxhafen Morgens $11^{h}\ 45'$ im Max. $14{,}29^{m}$
	Morgens 9 Uhr	Morgens 10 Uhr	30,7	NO.	21	
	Morgens 10 Uhr	Morgens 11 Uhr	25,7	NO.	16	
	Morgens 11 Uhr	Mittags 2 Uhr	19,4	NO. bis ONO.	8,66	
	Mittags 2 Uhr	Mittags 3 Uhr	19,4	O. zu N.	3	
		Mittags 3 Uhr 20 Min.	19,4 bis 16,8	O. zu N. zu O.	Höchste Fluth mit $3{,}17^{m}$ am Pegel	
		Mittags 4 Uhr	16,8	O.	Starkes Fallen	

The termination of the Schlei at its western terminus raises the water level by a small amount; the speed of the crest of the tidal waves averages about 0.9 miles per hour.

The characteristic phenomenon at most coastal points, especially at Travemuende (Travemünde), Sønderborg (Sonderburg) and Aabenraa (Apenrade), whereby the water stopped rising for a short time in the evening of November 12th, is the moment when the storm had actually reached its maximum after a normal course, but due to the sudden swinging of the equatorial current towards a narrow river bed, it increased its speed to the height of the hurricane and thus raised the water to the abnormal height.

The falling of the tide is characterized in comparison with the rising by the short time intervals in which the former occurred, and here the wind is unmistakably involved too. While the increase in wind intensity from NE begins already in the evening of November 10th and lasts until noon of November 13th, i.e. about 66 hours, the decrease comprises only about 18 to 20 hours, whereby it must be taken into account that in the meantime already the turn of the wind to SE prepared itself, which promoted the falling of the water.

For this reason, the falling part of all profile curves of the storm area west of Ruegenwaldermuende (Rügenwaldermünde) is unequally steeper, the area of the falling tide, Figure 16, is unequally narrower than the rising part, and only Barth, not lying directly on the open sea, shows the opposite, which will be discussed in more detail later when listing the destruction that occurred.

It is obvious that such a significant change of the water level after the completion of the force causing it cannot take place in a uniform return of the water level to the normal height, but in oscillations that result in an alternating rise and fall of the water, a uniform wave movement along the entire coast, and both the water level scales of the profiles, Figure 11 to Figure 16, show this, as well as the longitude profile of the Baltic Sea shown in

Figure 1. These oscillations last longest where the level difference was greatest, i.e. at Aarösund, and appear weakest at the neutral position of the whole level movement, i.e. at the level of Pillau. On average, the even level had already returned at Pillau on November 15th, but not at Aarösund until November 20th.

The tide, to the extent that it had to fill the inland waters, also raised the latter and generated a maximum water level above mean sea level of:

2.19 metres at Thiessow,
1.41 metres at Swinoujscie (Swinemünde)
0.84 metres at Dievenow
within the Oder estuaries:
0.65 metres at Lebbiner Bergen
0.58 metres at Wollin
0.88 metres near Stepenitz
0.76 metres near Szczecin (Stettin)
1.77 metres near Wolgast
1.13 metres at Anclam
above mean water level.

4.1.2 Currents

The Sound (Oeresund), which is one of the three straits connecting the Baltic Sea with the North Sea, will be considered as the most important of the three mouths of the Baltic Sea when evaluating the incoming and the outgoing current, since observations of these are available.

In the month of October 1872, according to the notices in the Baltic Sea newspaper, a current from the north, i.e. incoming (thus outgoing on 29 days), was only observed for the Baltic Sea on 2 days, namely on October 24th and 31st near Elsinore.

From November 1st to 10th, incoming current from the North Sea only occurred in the Sound:

throughout the whole of November 1st
for half a day on November 4th,
throughout the whole day on November 6th and 7th
and throughout the whole day on November 8th,
adding up to four and a half days of incoming current from the North Sea between October 31st and November 10th.

Observations of the current are also found at Aarösund and Sønderborg (Sonderburg), and indeed the current was:

		outgoing	incoming
at Aarösund in October	days	12	19
from November 1st to 10th	-	5	5
at Sønderborg (Sonderburg) in October	days	12	19
from November 1st to 10th	-	4	6

Between these two observations in the Sound and the area of the Little Belt, the former deserve preference, because with the low profile of the Little Belt, the influence of moderate winds and the locality can give rise to special phenomena, which make the occurrence of a continuous current clearer only with stronger wind movements. In the Sound, the outgoing or incoming movement of water depends only on the prevailing winds over the area of the North Sea and the Baltic Sea, insofar as the same is not conditioned by the slight influence of the tide and ebb in the Kattegat. Thus, during the period from October 31st to November 10th, within 4½ days, not only did the receiving water for the Baltic Sea basin stop, but at the same time large quantities of North Sea water were supplied to the Baltic Sea, and thus the mean water level of the latter had to rise considerably above the usual level. Taking into account that the prevailing westerly winds accelerated the rather constant incoming undercurrent of salty water into the Baltic Sea, the rise of the mean water level was a certain consequence of this air movement, since usually the difference in quantities between the outgoing upper current and the incoming undercurrent must be equal to the water supplied to the Baltic Sea of its precipitation area, reduced by the amount of the evaporation quanta.

Within the Baltic Sea basin, unfortunately only 3 of the gauging stations on the Baltic Sea record the movement of the coastal current. These are Colbergermuende (Colbergermünde), Ruegenwaldermuende (Rügenwaldermünde) and Stolmünde. In recent times, these observations have been supplemented by the stations established in the Baltic Sea by the Commission for the Investigation of the German Seas.

At Colbergermuende (Colbergermünde), the coastal current was:
from November 1st to 9th inclusive from west,
from November 10th to 14th inclusive from east
and then from west again.

At Rügenwalde the coastal current was:
from November 1st to 9th inclusive from the west,
from November 10th to 16th from east
and then from west again.

At Stolpmünde, at last, the coastal current was:
from November 1st to 4th inclusive from west,
on November 5th there was standstill,
from November 6th to incl. 9th from west,
on November 10th there was standstill,
from November 11th to 15th included from east
and then from west again.

According to the above, there is no need for further proof that, with respect to the direction of the current, abnormal conditions in favour of a supply of North Sea water to the Baltic Sea prevailed in the period from October 31st to November 10th.

During the northeast current, the current had to take the direction of the Belts or the Sounds, respectively, on the coasts it had to take the direction of the storm. In the Lübschen fairway the coastal current running north from the Trave to Neustadt met the oncoming sea state at Pelzer Haken where it created a great choppy sea with complete eddies. Outside Pelzer Haken to Fehmarn, meanwhile, the coastal current resumed its northerly direction. In the Fehmarn Belt and Sound, strong currents from the east occurred throughout the tide. At Bülk, off Schleimünde, at Alsen, and at all points of the Little Belt, a strong northward current was observed.

4.1.3 Salinity and Specific Weight of the Baltic Sea Water

Since the salinity of the Baltic Sea water is on the average different from and lower than that of North Sea water, and these two waters communicate, consideration of the observations of the specific gravity (which increases with the increase of the salinity) of the water in different parts of the Baltic Sea will serve to elucidate the causes of the height of the storm surge.

Since salinity and specific gravity are inseparable concepts, it should be mentioned here that an increase of 1% in salinity causes an increase of 0.007639 in specific gravity, and that accordingly each increase of 0.01 in specific gravity causes an increase of 1.309% in salinity.

At Sønderborg (Sonderburg), where the annual average of the specific gravity of the water is 1.01308 t/m³, the same was found to be l.01518 t/m³ on November 1st, l.01648 t/m³ on November 5th, and 1.01859 t/m³ on November 9th with maximum salinity in the period from November 1st to 20th.

If the salinity of the water at Sønderborg (Sonderburg) is calculated, the average salinity is l.7l2%, the content on November 1st is 1.987%, on November 5th 2.157% and on November 9th 2.434% and the increase of salinity on November 1st is 0.875%, on November 5th 0.444% and on November 9th 0.722% against the annual average.

If no further annual means of other stations are available, it will be useful if results of some stations are brought together and compared among themselves because of their absolute differences.

At Fehmarn Sound (Fehmarnsund), the specific gravity of the water was l.00925 t/m³ on November 1st, 1.00947 t/m³ on November 4th, 1.00959 t/m³ on November 7th (maximum from November 1st to 20th), and l.00914 t/m³ on November 9th. Calculating the salinity, we find that at Fehmarn Sound (Fehmarnsund) it was l.211% on November 1st, 1.240% on November 4th, l.255% on November 7th, and 1.196% on November 9th.

At Nowy Port (Neufahrwasser), finally, the specific gravity of the water on November 1st was 1.00638 t/m³, on November 5th only 1.00553 t/m³, but on November 11th it reached the maximum with 1.00751 t/m³.

If we also calculate the salt content of the water, we get 0.835% on November 1st, 0.724% on November 5th and 0.983% on November 11th.

For a better parallelization of the observations, it may be noted here that, taking as a basis the fact that the salinity of the water of the Baltic Sea is significantly lower than that of the North Sea, and that this decrease occurs first more rapidly and then more slowly from west to east, Dr. Oscar Jacobsen, on the Pommerania, has found that the salinity of the water of the Baltic Sea is lower than that of the North Sea. On the Pommerania during the expedition to investigate the German armies in July 1871 from Kiel Bay to off Darserort, Oscar Jacobsen found salinity to be from 1.330% to 0.932% from the northern tip of the island of Rügen to east of Bornolm from 0.771% to 0.789%.

The supply of salinity from the North Sea usually occurs, as long as the Baltic Sea is draining, through an undercurrent, which up to now has been observed at Sønderborg (Sonderburg) incoming as often as outgoing.

Since it is obvious that any wind direction that retards the general upper current of the Baltic Sea, respectively capsizes in the incoming current, an acceleration of the undercurrent may also be assumed, which will therefore have taken place in the period from October 31st to early November and must increase the salinity in the western basin of the Baltic Sea.

A further confirmation of this supply of stronger salt water from the North Sea is based in the glow of the Baltic Sea in the autumn of the year 1872, as had never previously been seen in living memory. However, stronger chemical stimulants for the glowing animals belong to the glow of the sea, as earlier experiments of Ehrenberg taught, who poured some diluted hydrochloric acid into the water of the Baltic Sea and brought the little animals contained in it to the momentary glow.

4.2 The Causal Connection of the Phenomena for the Occurrence of the Tide

Summarizing the previously listed facts on wind and water movement, as well as the current and the salinity of the Baltic Sea water, a picture emerges which depicts the storm surge of November 12th–13th, 1872, as an exceptional revolution of the elements air and water as far as history goes.

The fact alone that the current in the Sound was outgoing for the Baltic Sea during the entire month of October, with the exception of two days – on October 24th and 31st – proves, if one assumes that during effective westerly storms the Sound, the Great Belt and the Little Belt are subject to a similar current – that the influx of North Sea water causing the abnormal height of the storm surge and the accumulation of inflows from the precipitation area took place immediately before the storm surge itself.

This grant of North Sea water will have occurred, albeit intermittently, from October 31st. On November 1st, after the flow had already been incoming for the Baltic Sea under the same influences from the morning of October 31st, a storm from the southwest raged over the North Sea and the Holstein coasts, which, decreasing to strong and moderate winds, also moved over the basin of the Baltic Sea as far as off Koenigsberg (Königsberg), where a storm from the southeast was weaving at the same time. This southwest storm kept the current in the Sound as incoming for the Baltic Sea also on November 1st during the whole day.

The water levels of the Schleswig-Holstein stations, which were 0.5 to 0.8 metres above mean sea level at noon on November 1st, prove that large water masses from the North Sea entered the Baltic Sea during the two days of October 31st and November 1st.

This southwest storm could not and cannot at all quickly compensate for the subsidence caused by it in the southern basin of the Baltic Sea by the incoming current from the North Sea; for on November 1st, the water at Ruegenwaldermuende (Rügenwaldermünde) and Stolpmünde had fallen about 0.25 metres below the mean water level, i.e. the water masses had been diverted to the northeast by the southwesterly storm. (Coastal flow was from west to east).

On November 4th, however, the inflow of North Sea water and the buildup of the receiving water became visible in front of the two latter stations, where the water had risen by 0.5 metres, i.e. to about 0.25 metres above mean water since November 1st, although the wind had not changed its direction, but remained at a fairly constant strength on the west side of the Baltic Sea.

Even if on November 2nd and 3rd the current in the Sound was outgoing for the Baltic Sea, the persistent air flow from the southwest justifies the conclusion that only a weak surface current took place in the Sound, which by no means satisfied a full pre-flood. This assumption is also in agreement with the annual observations of the Danish Lootsen (Pilotes') Administration, which shows that the current in the mouths of the Baltic Sea is already fluctuating with ordinary southwest winds, unless strong wind speeds lead to a subsidence in the western basin of the Baltic Sea and thus cause a stronger current from the north.

The same game is repeated in the following days.

On November 4th, with the general wind direction still prevailing from the southwesterly quadrant, the current was incoming in the Sound as a result of moderate northwest winds in the Kattegat for the Baltic Sea. In the afternoon, the wind jumped up to west northwest and dropped back to southwest on November 5th; and therefore, on November 4th in the afternoon as well as on November 5th there is outgoing current again. This continued until the afternoon of November 6th. Then, on November 6th rose the significant westerly storm, which passed the English and Scottish coasts, fluctuating between west northwest and southwest - blowing from west in the eastern stations of the Prussian coast, completely encompassing the North Sea.

In the so-called Lübische Fahrwasser, Travemuende-(Travemünde)-Darserort, the water level sank almost 1 metre below mean water at noon on November 7th, while at noon on November 6th it was still 0.25 metres above mean water on average. The lowering of the level extends steadily upward to the neutral axe at Pillau. The gradient towards the Baltic Sea increases and the incoming current carries the North Sea water towards the Baltic Sea at a corresponding speed. This persistent westerly wind, lasting until November 9th, gave the incoming current sufficient time for the water to flow in.

At noon on November 9th, the water in all stations was already up to 0.25 metres above mean water.

In Koenigsberg (Königsberg), the storm continued until 9 a.m., and accordingly, a significant inflow of water into the Baltic Sea must have occurred in the meantime.

Quite in harmony with these movements is the increase in the salinity of the Baltic Sea water for:

Sønderborg (Sonderburg) from November 1st to 9th by 0.447,

Fehmarn Sound (Fehmarnsund) from November 1st to 7th by 0.044,

Nowy Port (Neufahrwasser) from November 1st to 11th by 0.148.

It should not be forgotten how the incoming North Sea water mixes with the Baltic Sea water, depending on the size of the part of the Baltic Sea basin passed through and the swell there.

The outgoing current observed in the afternoon of November 7th in the hour is, like the outgoing currents discussed above since October 31st, only of short duration and is of no importance.

The earlier discussed storm from west northwest to southwest on the evening of November 6th had reached its end on November 8th, between Rugen (Rügen) and Pillau only in the evening of November 9th, and changed very quickly into a strong wind and then decreased to moderate speed, so that on November 10th even calm winds are reported by several stations, and very calm winds from southeast, south to southwest at the remaining stations. During this weak wind or calm, respectively in the westernmost and easternmost stations, the northeasterly has already sent its first forerunners between Rugen (Rügen) and Stolp. Therefore, the uninterrupted further rise of the sea can no longer be explained by the inflow from the west, but by the water masses dammed up in the east and north, which partly followed their own gravity, partly were pushed back by the beginning northeast wind. These water masses, now evading to the west, were followed by the north-east, which gained in terrain as well as in intensity, so that now, progressing from west to east, a continuously faster increasing rise of the tide occurred, which seemed to have reached its climax in the evening of November 12th, since at several stations, especially the western ones, a standstill of the rise of the tide, an equilibrium between wind strength and level change of the sea level, was observed at that time.

If one takes into account that on November 9th, as a result of the westerly storm, the level on the western side of the Baltic Sea had risen by almost 1 metre, decreasing accordingly towards Pillau, the water level line at noon of November 12th was by no means an abnormal one under the average northeasterly wind, which was not yet stormy. Rather, it was one corresponding to the previous course of natural phenomena, which on the whole seems only moderately influenced by the northeastern wind.

The pause that occurred in the evening of November 12th can only be explained by the fact that the pressure of the water accumulated to the west was in balance with the intensity of the NE wind blowing at that time.

Only the hurricane occurring shortly after midnight near Colberg was able to reshape the level line of the Baltic Sea existing at 12 p.m. (see Figure 1), which corresponds in its entire inclination to the level differences occurring during similar events, now favourably prepared, in a way as it appears in the three further level lines of November 13th.

The overcome force of the water can be recognized quite clearly by the now changed direction of the level lines on Figure 16. Up to November 12th these show an inclination from west to east at night or a leading of the tide rise on the west side against the east side. This advance is weakened at midnight, the lines become less inclined from west to east, and at noon on November 13th they already reach a parallel position to the time horizontals lying as abscissas.

It is precisely in these successive stages of the flood period that caused the intense development of the enormous swelling of the water on the western side of the Baltic Sea basin, which, according to the above description, is thus characterized in three stages, namely:

In the period from October 31st to November 9th filling of the Baltic Sea with North Sea water and end of the inflow closure of the foreshore.

In the period from November 9th to the evening of November 12th, oscillation of the Baltic Sea water to the west with the basin overfilled.

On November 13th, impact of the northeast hurricane on the western part of the Baltic Sea, the level of which had already reached a significant height due to the preceding events.

Notes on the wave height were obtained from the Neustadt construction district by the district master builder Heydom. These are for some main points above the highest water level

at Sierksdorf	1.50 metres
at Neustadt	0.25 metres
at Pelzerhaken	1.75 metres
at Kellenhusen	1.75 metres
at Dahme	2.00 metres
inland at Grabe	1.00 metres
at Fehmarsund on the Holsteiner side	2.00 metres
also on Fehmarn side	1.50 metres
at Heiligenhafen	1.50 metres
at Flügge	1.00 metre
at Albersdorf	0.50 metres

at Lemkenhagen	0.30 metres
at Westermarkelsdorf	1.00 metre
at the Weissenhäuser bridge	1.75 metres

The size of the swell on the more northern coasts of Schleswig is given, according to fairly consistent data, as 4 metres wave height, i.e. to 2 metres above high water, while in the bays it has decreased to 2 metres, i.e. to 1 metre above high water.

The height of the waves moving against the high shore was, of course, greater. At Schleimünde, the waves have risen to the top of the 50-feet high lighthouse standing on the head of the northern breakwater and have at times enveloped it to such an extent that it could not be seen from Maasholm, 0.5 mile away, and was considered lost.

5 Remarks on the Above

At the end of these results concerning the phenomena of the storm surge, it must be added that there are difficulties involved in collecting sufficient observations for such natural events because in many cases such observations are incomplete and incompletely carried out.

The meteorological material is least complete and is then least sufficient when its procurement is most necessary, namely at the time of extraordinary deviations from normal conditions. The intention was also to include a short note on the storm tide of February 9th–10th, 1874, which was also of great interest, but this was impossible due to the lack of sufficient observational material. One of the first requirements for a future central office for oceanography will therefore be to obtain the observations in a completely uninterrupted sequence if it wants to reliably fulfil its task. With phenomena in the atmosphere developing so quickly at times, punctuality and speed of submission of these observations to the collection point will become an unquestionable necessity.

With this material, the observations obtained at the pilot stations, which are characterized by a greater certainty with respect to the wind directions, since the observations of these stations are rarely clouded by local conditions, should not be underestimated, and in addition, the observations of the sea conditions with respect to water level, current and direction, as well as the strength of the swell, constitute valuable observations that support the conclusions to be drawn. Breaking winds are sometimes preceded by rolling with a corresponding swell, which may well mark the upcoming events. Self-registering tide gauges in the Baltic Sea at the pilot stations have only been installed in Swinoujscie (Swinemünde). It would be advisable to install them at several suitable stations and thus to obtain tide curves in a more reliable form than allowed by temporary observations, which suffer from uncertainty at night in particular. The representation of the tide curves in profiles, which are obtained from the registration of temporary observations, as was done in the present case to supplement the intermediate elements, constitutes an interpolation rather than an observation, forming only a poor substitute for the lack of material.

More far-reaching than up to now, the observations from the south would have to be obtained for the meteorological stations, insofar as they cover the area on which the equatorial current moves, before the incursions of the polar current into the Baltic Sea give rise to the storm surges in this area. This seems all the more necessary, since the phenomena occurring here generally precede the catastrophes in the Baltic Sea by days, and the same therefore substantiate the forecast more securely.

6 The Hydrotechnical Phenomena of the Storm Surge

In the following, the effects of the storm surge on the natural as well as on the artificial boundaries of the Baltic Sea, as well as the resistance of the existing structures are described as they have resulted from the official reports or from own observation of individual localities.

For orientation in the localities, however, one will have to use special maps, especially the Prussian Sea Atlas of 1841 and the map of the Duchies of Schleswig, Holstein and Lauenburg, by Geerz.

6.1 Natural Boundaries and Waterways

6.1.1 Sandy Beach

District of Szczecin (Stettin)

The beach has increased in width almost throughout and in stretches very significantly. Between the piles in front of the Streckelberg, the beach has formed advantageously. In general, the foot of the high shore or the foredunes has receded everywhere, so that the piles at Streckelberg have lost their connection to the shore. The widening of the foreshore is a consequence of the break-off of the high bank or the dune, which had covered the foreshore with material.

District of Schleswig

Since the destruction on the coasts is mainly due to the effect of the swell at a more than usual height, the shallow, low lying, and therefore immediately flooded sandy beach has suffered almost no changes at all because it was exposed to lesser attacks. There are very few larger dunes at this beach. Instead, the beach consists mainly of a gravelly material, which is tossed up higher with the waves and is often called Haffstock. The high tide has changed this stock in that the material has been hurled with the waves over the top of the gravel wall so that the entire sand and bedload wall lying parallel to the coast has made an inland movement. The size of the movement itself cannot be determined; in general, the beach here is a beach divided many times by inlets, which does not continue in coherent lines and therefore a material migration is carried out to an even lesser extent, as the coastal currents also occur in a less intensive form than on the Pomeranian coastlines.

6.1.2 Clay Bank

District of Szczecin (Stettin)

The clay bank in front of Groß-Horst has been washed away because of the too low position of the stone revetment in front of it.

Also in the vicinity of the church at Hoff, several break-offs of the high bank have taken place.

District of Schleswig

The clay bank has broken off almost everywhere to a considerable extent.

Depending on the location of the bay the banks of the Lübschen Fahrwasser were affected most by a northeasterly storm.

In the southernmost corner of this bay, the Trave flows into the sea in a northeasterly direction. Half a mile west of the mouth of the Trave is Lake Hemmelsdorf, 500 ha in size. Between the two bodies of water there is a plateau rich in hills, 30 to 45 metres high, which borders the Baltic Sea with a convexly broken off shore, the "Brothener Ufer", up to 20 metres high. From the width of the Brothen shore as a base, a 3/8 mile, 1¼ mile high isosceles triangle extends into the sea, whose clayey bottom, gradually dropping to 17 meters water depth, is covered with many large stones (erratics), and is therefore called "stone reef".

The beach in front of the Brothen shore is very narrow, rises to the foot of the shore about ½ to 1 metre above mean water, and – like the reef - is covered everywhere with large stones as residuals of the broken clay shore.

Each sustained high tide washes away the foot of the high bank, which is followed by a post-fall of the upper clay masses, which often cover the beach in large blocks, like mountain debris. These are washed away by the next high tide and only the stones they contain remain on the beach. Since time immemorial, entire plots of the best wheat soil have disappeared from the heights of the Brothen shore. In this storm tide again considerable areas have fallen from the height into the sea.

These processes of the present have been repeated since time immemorial, and as far as lore goes, the waves have not only made an elevation over 1 mile long disappear completely, but its debris has already sunk as a stone reef to a depth of 17 metres under water. Every sustained easterly wind, which drives the waves over the stone reef, gives the water in the southwestern part of the bay a clay-yellow colour, even when little or no clay is washed away at the level of the foot of the Brothen shore; this is a sign that the waves are still attacking the reef at sea.

The precipitation from this murky water makes itself unpleasantly noticeable eastward by closing the Travemuende (Travemünde) fairway. West of the stone reef, this clay silt is found deposited in the northern part of Hemmelsdorfer See, the so-called shallow lake, which has a depth of only 4½ metres in the extension of about 400 ha, while from the bend on, in the eastward bent southern tip, which is protected against NE, the bottom of the so-called deep lake drops abruptly to 43 metres.

The northern part of the shallow lake becomes shallower and shallower towards the Baltic Sea. Up to 1½ metres water depth it has extensive cane and reed stands, which also still form small groups at shallow places with elm and willow bushes, until a grass felt has built the first dam over the lake bottom; this is so weak that one always finds oneself in a wave valley when crossing; it is so broken through that one has to use caution not to step through; but towards the sea it becomes more and more solid.

To protect this lowland, that is the lake and a strip of meadow about ¼ mile wide, the sea itself has thrown up the material and the wind has built up a sand dune out of this material about 3 metres high.

The assertion, based on this account, that the lowlands of the Hemmelsdorfer Sea were once a part of the Baltic Sea and were separated from it by the silt of the Brothen shore, and later by a dune, should be all the more evident from the foregoing if it is added here that sea shells, sea grasses, and rounded beach stones have been found in the bottom of the meadows bordering the lake.

The clay share has also broken off at other points along the coast, although the phenomena that have occurred here have occurred on a less grand scale than on the Brothen

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shore with the exception of the stretch of coast from Heiligenhafen to the Bröck in the Hohwachter Bucht, this is true on almost all high shores as well as between Haffkrug, south of Neustadt, and Grömitz, north of Neustadt, from Dameshoeved to Dahme, from Siggen through the Fehmarn Sound (Fehmarnsund) to Heiligenhafen, from Staberhuck to Gahlendorf on Fehmarn, at Weissenhaus west of the Bröck, off Hohenfelde and Schmel, on the ½ mile long clay wall, from Stein to Laboe in the Bay of Kiel, at the lighthouse establishment at Bülkerhuck, on the Schwansen coast between Langholz and Boknis, off Schönhagen, as well as on the high shores of the Angeln countryside, on the east and north coasts of Alsen, and between Apenrade and Gjenner Bay.

Apart from the coastal location, the geological conditions of the clay shore have been of essential importance for the extent of the erosion.

The solid subsoil is almost everywhere formed by a blue-grey, very resistant clay marl, the surface of which rises several metres above the daily water level, but in places also sinks below it. On this subsoil lie in various directions, interspersed with larger and smaller boulders, other clay and loam masses that are easier to dissolve in the water, sometimes alternating with sand layers, but also containing only individual larger sand masses or sand bubbles. According to the occurrence of the sand, the type of erosion has been very different. The sand bubbles were washed out by the water and as a result caves were formed, which were still present up to 10 metres depth after the storm surge. However, the caves were mostly buried during the storm surge by the unsupported softened clay mass hanging over them, and this was soon licked away by the oncoming wave.

However, these break-offs did not take on the dimensions of those that took place on such stretches of shore where a layer of sand was continuously embedded. The latter was soon washed out and as a result the soil above this layer was washed away. The nature of the erosion can still be clearly seen in the contours of the shore; while these follow more the straight or evenly curved line of the beach on the stretches of coast with continuous sand stratification, the clay shore with injected sand bubbles shows the most peculiar irregular formations, to the extent that firmer material was encased by the more easily soluble material.

A short time after the storm surge, the clay walls were dull and reflective, and in some places the most resistant material, the clay marl, had taken on almost the pointed forms of basalt in individual blocks that had remained standing. Later, the soil debris collapsed and an embankment with the usual slope for this type of soil was formed.

The extent of the erosion on the clay bank as a result of the storm tide of November 12th–13th, 1872, could only be determined by the fiscal lighthouse establishment at Bülkerhuck, since exact terrain surveys from the time shortly before the destruction in other cases were not available.

The attached situation drawing in Figure 17 of the named establishment, however, gives insight into the size of the demolition there in the years 1868 to 1872, whereby it is to be noted that up to the time of the last storm tide a substantial change in the borders against the sea had not occurred since 1868.

The area used for farming at Bülkerhuck was:

in	1806	20 acres,
-	1868	16 acres-
after the last storm tide		13 acres-

It was not evident in all of the cases where the eroded clay was taken by the sea. Almost everywhere, the sea had taken on a clay-yellowish-grey colour, which in the bays partly disappeared only after 4 weeks.

The material deposited at Bülkerhuck consists only of sand and rubble; the clay content of the washed-up shore dissolved in the water has continued and was probably deposited on the seabed near the coast only after the calm of the sea had set in. This at least is supported by the observation that on the formerly white seabed in Strander Bay, between Friedrichsort and Bülck, there is now a thin yellow layer, apparently clay, which can only come from the quarries near Bülckerhuck.

6.1.3 Dunes

District of Gdansk (Danzig)
The dune structures suffered only on a short stretch on the Hela peninsula near the new lighthouse at Heisternest. Here, waves rose up to 3.20 metres above the mean water level, destroying part of the newly established pre-plantings and attacking the base of the dunes. No other pre-plantings suffered significant damage. On the contrary, it should be emphasized that calamities, such as the overturning and silting up of river mouths, e.g. of the Piasnitz River on the western border of the administrative district, which always occur during higher storm surges, were not noticed after the storm surge in question.

District of Coeslin (Cöslin)
The foredunes on the coast of the Coeslin (Cöslin) governorate (Regierungsbezirk) have been considerably damaged.

Since the wind direction at the time of the strongest current hit the rear Pomeranian coast at a very acute angle, the water level (cf. the profile on Figure 1) did not reach such a considerable height here as it usually does during strong storms, and especially during the storm that raged in November 1867, the water rose much higher.

The wave action, however, was very violent, and it is to this that the beautifully cultivated foredunes have been attacked to such an extent that almost the third part of them has been completely destroyed and must be laid out anew.

The advantage of the foredunes, however, has been unmistakable, since they have protected the main dunes from heavy demolition.

Severe damage to the main dunes has only occurred in places where there were no foredunes.

District of Szczecin (Stettin)
Along the beach, from Swinoujscie (Swinemünde) westward to below Hammelstall, the foredunes, the grass plantations and the old fences have been washed away by the sea; mostly the older dunes have also been attacked very severely, up to a width of 10 metres, and the front row of them has even been partially broken through, especially at Cölpiner See, near Damerow and Zinnowitz.

The break near Damerow is the largest and also the deepest. It extends about 150 metres inland with an average width of 50 metres and a depth of 1 metre below the average water level of the Baltic Sea. On the beach, the depth was only 0.3 meters and the inland meadows have a height of 0.5 metres above the mean water level of the Baltic Sea, so that after the fall of the tide the water no longer flows through and, consequently, there is no seepage causing the ground to break.

In order to get a full understanding of this collapse, it must be noted that where the tide cannot enter inward because the dune or the high bank rises above the tide, the beach only forms in evenly curved lines in the situation and that sudden deep cracks can only be the result of an outgoing current. This has also taken place at Damerow, where the tide overflowed the low terrain and poured into the backwater, raising this inland basin in water level. With the rapid fall of the lake level, the high inland water poured over the low terrain towards the lake and cut a stream channel, which became deepest where the overthrow took place, while towards the lake a smaller depth was maintained, since here the water receded only slowly. That part of the inland water that is deeper than the low foreland had to pass through the Peene near Wolgast and created a longer lasting outgoing current in the outflow of the Peene, which could only have a favourable effect on the deepening of the Peene outlet, especially on the barrel bank. This phenomenon was repeated after the flood of February 9th, 1874.

The dunes between Ahlbeck and the western pier, as well as in front of Dievenow, have also broken off in significant width.

In the Fritzow dunes a breakthrough with flooding has occurred, but to a lesser extent than at Lake Cölpin. The width of the beach has increased significantly both landward and seaward, as everywhere.

District of Stralsund

Darsser Ort and Dars Peninsula:

The dunes along the west side of the Dars in the Ahrenshoop field on the border with Mecklenburg are completely destroyed, from there to the tar kiln south of the Dars lighthouse they are badly broken off; from here north and then west to halfway to Prerow the foredunes are almost completely destroyed, while from there to the Prerow stream they are badly damaged and in part completely destroyed.

Zingst Island and Sundische Wiesen (eastern part of Zingst Island):

The dunes are completely destroyed except for a short stretch east of Lake Papen at the Prerow Stream and small remnants near Prahmort. The destruction of this peninsula will be discussed in more detail in the section on dikes.

Hiddensee Island:

The insignificant dunes have suffered greatly on the whole island and are completely destroyed in front of the village of Vitte and its field, as well as in front of the villages of Plogshagen and Neuendorf, also on both sides of the breakthrough south of Plogshagen, while they have suffered greatly on the rest of the island and also on the Gellen.

Opposite the village of Vitte about 6 and near the breakthrough 1 bank collapses had formed. The latter find their cause in the same conditions as at Damerow, in that smaller lowlands had absorbed so much water during the storm surge that after the sea had fallen an outflow was formed by the drainage, which produced these incisions.

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Wittower Post House on Rugen (Rügen):

The small dunes on the Bug are very badly affected, partly completely destroyed, especially in the northern part of the Bug. The part initially located south of the land belonging to the municipality of Dranske, the so-called neck, that thin outlet of the Bug to the Wittow peninsula, has been washed away so considerably in a length of about 136 metres that, with an average width of 3.6 metres, it is still only 50 to 60 centimetres above mean water at the lowest point, while on both sides it rises to 1.7 metres above the same. The subsoil of this low-lying land connection consisted of clay covered with a layer of gravel. Since an inland water, the Wyker Bodden, is situated behind it, a strong overcurrent is generated here, which made an attack of this place all the more violent and caused its subsidence. During the storm tide of February 9th–10th, 1874, the surface of the terrain strip sank to slightly below mean water and this caused a fortified ridge to be built here to prevent a decisive ground failure.

Thiessow at the Southern Tip of Rugen (Rügen):

The entire dune range from Thiessow to Lobbe and from Lobbe to Göhren and at the southern tip of Thiessow has been destroyed. The part of the dune range from Thiessow to Lobbe was washed away at about 5 a.m. on November 13th and from then on the Baltic Sea poured through this dune breach through the Hagensche Wieck and the Zicker lake into the Greifswalder Bodden and the Rügen Bodden, so that the water here is said to have risen by about 1.25 metres in about 2 hours, while at the same time the tide around the southern tip of Rugen (Rügen) took its way to the same basin. The eastern outlet of the Thiessower Höft, a front head, was very strongly attacked by current and swell and the debris of fallen clay masses lay in large parts at the foot of the Höft.

Ruden Island:

On the island of Ruden, the dunes on the eastern beach have been almost completely washed away, and only at the northwestern tip are weak dune ridges still visible. High tides of the same type completely submerge the island, with the exception of a few higher dune crests.

District of Schleswig

True dune formation on a larger scale is not found on the east coast of Schleswig-Holstein. On those stretches of shore where a shallow beach forms the boundary of the sea, the waves have raised an embankment by washing out and accumulating coarse debris, which they rarely cross. In some places, namely on the Schwansen shore and on the north coast of Fehmarn, these dune formations have risen to a height of more than 3 metres.

During this storm surge, these dune-like embankments did not flood and also remained intact in their well scarred outer slope, partly covered with heather instead of beach grasses. The discussed formation of dunes on Fehmarn has even been intensified by the flood in that the masses of sand and debris churned up by the surf have been thrown out of the sea onto the lagoon and have created an elevation of the same, as well as the formation of an approximately 5-fold seaward slope, whereby, without the foot of the dune having receded, the top of the same has moved about 10 meters further inland, the dune thus having become that much thicker.

The beach wall located at the Schmöler and Stackendorfer beaches, as well as in front of the Probsteier salt marshes proved less resistant. It had an average height of barely 3 metres and was at its lowest point not less than 2½ metres high, consisted of sea sand planted with beach grass and had an irregular shape and slope, sometimes formed a rounded ridge, sometimes a more dike-like shape and in such strong dimensions that the thickness of the wall, measured 1½ metres below the upper edge, was at least 20 to 30 metres and in many cases considerably more. The direction of the beach wall went from eastsoutheast to westnorthwest so that the same in the outer slope against eastnortheast during the storm surge was hit by strong sea state.

At 7 a.m. the eastern part was destroyed first, the western about between 7:30 and 8 a.m., so that the destruction of the whole 1.5 miles stretch was completed in an hour, and, according to information given on the spot, down to about 1½ metres below the former top.

According to the Kiel observations, a water level of 2.15 to 3 metres above zero occurred from 7 to 8 a.m. Now, even if the same water level may not be assumed to have prevailed in front of the beach stretch in question, so much seems certain that an overflow of the 2½ to 3 metres high embankment could not have occurred during this time. Therefore, the effect of the swell and the overturning of the waves on the irregular, albeit very wide, sand body is to be stated as the cause of the destruction.

In the very shallow and evenly sloped solid beach ridge that remained after the upper part was washed away situated about 1.5 metres above mean water, some hydraulic heave has occurred. Here the lower material is uneven and less firm, or the embankment at such a place was particularly low and therefore here water passed over the same.

The even weaker, only 2 to 2.5 metres high beach dune with about 12 times the outer area, covered with individual beach grasses, as they occur among others at Waterneversdorf in the Hochwachterbucht, apart from on the described stronger dune also at the Schwansener Strande, in front of the Schlei, on the peninsula Kekenis located south of Alsen, etc., has - apart from a few dunes and some breaks as a result of overflowing at low places – essentially preserved its form, but has moved inland by about 10 metres in its entirety, whereby the drainage channels on the seaward side have been exposed and buried on the landward side. The sea has carried out this work with great regularity, and from the observation of this careful natural dam formation, often extending for miles, it becomes understandable that the popular belief, which could not explain such an effect, has attributed the formation of the sacred dam at Dobberan to a saint who built it at the command of the monks in one night for the protection of the monastery.

The breaches that occurred in the dunes described above took place off the coast of Schwansen without exception at those places where, in order to get to the beach, one had to drive over the dune. Here there will have been low, rugged places, over which the water first passed and fell with a strong gradient into the lowland behind the dune. Considerable scouring in the affected terrain confirms this course. Therefore, special care must be taken in the construction of such crossings to avoid such destruction.

The dune formation, weakest in its dimensions, which occurred especially in the inland part of the district of Oldenburg, consisted of loose drifting sand, mixed with sea grass and small debris, and almost everywhere reached only an equal height of 1.5 metres above mean water. The crest and landward slope were usually sparsely covered with beach grass and other beach vegetation, which was insufficient to prevent the sand from blowing away and the resulting constant variability of the dune. Nevertheless, even these weak beach dunes provided substantial protection against the lower tides of the Baltic Sea by keeping the ordinary high tide from the lands behind them, most of which rise only a few feet above the mean water level.

As a result of this storm tide, these low beach dams, as far as they were exposed to wave action, almost completely disappeared and collapsed into the lowlands behind them, so that now a tide only 0.75 metres high would already flood them.

There has been a lack of deliberate dune cultivation on the Baltic Sea in this administrative district. Only on the Lootsen Island at Schleimünde were plantings of sand grasses and fences made, but only on a very small scale. These have completely silted up as a result of the shifting of the dune described above.

6.1.4 Transverse overflows of Fairways, Reduced Water Depth, Deepenings etc.

District of Gdansk (Danzig)
There has been no change in the depth of the harbour's entrance line to Nowy Port (Neufahrwasser).

District of Coeslin (Cöslin)
The storm has had no noticeable effect on the depth in the mouth of Colberg harbour. The mouth of Rügenwalde harbour, on the other hand, was so silted up that here, where there is usually a depth of 3 metres, only a water depth of about 2 metres remained.

The storm had a very favourable effect on Stolpmünde harbour. Here, a bank moving from west to east had pushed itself so far in front of the harbour mouth that only in the northeast direction a 3.75 metre deep entrance channel was open, making it difficult for ships to enter in SW winds. After the storm, this sand had completely disappeared, and a depth of 3.7 to 4.4 metres had formed in the whole sea gate.

District of Szczecin (Stettin)
The fairway of the Dievenow has shifted a lot. The sand masses on the shore breaks have been deposited here and in the fairway at Falkenberg. The water depth in the harbour entrance to Swinoujscie (Swinemünde) has not changed, whereas the smaller outlets on the coast, Camper Lake, Rega, Liebelose, Dievenow, Schlohn – with a significant shift to the west, have shown strong but only short-lasting drops in water depth.

District of Stralsund
Stralsund Harbour. The water depth had decreased by about 30 centimetres right at the exit from the harbour to the fairway channel, across which the stream cuts.

No further decreases of water depths in the harbour were noticeable. Likewise, it is noted that the depth of the outer parts of the dredged channel leading to the stream has remained unchanged.

City of Barth. In the channels and gullies leading to the shipyards, drops in water depth of up to 1.25 metres have appeared.

Wittow Post House. In the Libben and the channel near Alt-Bessin the water became moderately shallower by about 0.31 metres.

District of Schleswig

Transverse overflows of fairways have only occurred in a few places and, as a natural consequence, no significant reductions in depths of the fairway have been observed.

The piers at Burg auf Fehmarn, made of fascines and stone packings, extended only a few feet above mean water. They were therefore soon submerged and no longer capable of holding back a significant amount of seaweed, which had been lying in the corner between the northern harbour pier and the Kirchberg near Burgtiefe and had been picked up by the water.

As a result, the seaweed was deposited in the dredged harbour channel, reducing its depth by an abundant 0.5 metres.

At Schleimünde, the 2.8 metres high and the 1.8 metres high end wall built at the root of the northern breakwater, which lie side by side at the NW end of the structure behind the dune, had not yet been backfilled on November 12th. The storm tide did an excellent job on the 9 feet wall, but oversanded the 1.8 metres high wall by 3 feet and carried significant masses of sand over it into the Schlei. Effective measures prevented the siltation from reaching the fairway on this occasion.

If, moreover, no soil deposits have taken place to such an extent that depth reductions or constrictions in the fairway could be noticed, the reason for this is to be found in the fact that in all narrows and in the harbour mouths a very strong outgoing current prevailed with falling water.

However, special deepenings caused by this storm were only noticed in Eckemförder Harbour. Here, the dam closing Windebyer Noor was torn away by the storm surge, whereupon the tide entered the approximately l/8 mile large inland basin, Windebyer Noor, and deposited the material of the dam in large banks in the Noor. The water that has penetrated here has caused washouts up to 3 metres deep as it drains into the narrow part of the inner harbour, and even on the barre in front of the harbour there is still a depression of 0.7 metres.

6.2 Artificial Bank Protection Structures

6.2.1 Groynes

District of Coeslin (Cöslin)

The pile groynes in front of the high clayey shore at Jershöft have proven themselves well and have contributed considerably to the protection of the shore. The construction consists of 2 rows of piles about 0.18 metres thick, which are driven close together so that the joints of the inner row are covered by the piles of the second row. This double pile wall is cut horizontally at mid-water level or 0.15 metres above it and runs under the beach embankment without any particular fixed connection to the high bank. Its purpose is to keep the depth away from the beach, to widen the foreshore by accumulating sand, and thus to be conducive to the culture of the foreshore dune without altering the natural beach slope, which would not be achieved with a higher crown of works. Partially, the construction of only one row of piles has already served the purpose.

These pile groynes have held up well. Only three groynes at the eastern end of the system have been washed out and become rootless.

Even if deep holes have not been torn out, the connection to the foreshore will have to be restored.

District of Stralsund

Zingst Island:

The pile groynes, which were built along the beach to facilitate the landings, have been damaged in many places and, in particular, many of the piles consisting of a row of piles, both at the heads and in the middle, have been torn out; the pile works adjacent to the beach have also been largely bypassed by the tide. Since the flood, most of the piles have been re-siltated. On the whole these destructions are beyond the measure of the usual destructions. The similar works locally inspected after the storm of February 9th–10th, 1874, before the breach in the beach at Damerow, administrative district of Szczecin (Stettin), showed the same characteristics. Both points are consistent in that the tide overflowed the lowland and that both the incoming tide took the agitated sand of the foreshore inland, and the outgoing tide threw any remaining material further out to sea, causing the waterline to recede considerably. In addition, the works, especially by the incoming and outgoing current, entered into a substantially different attack than for which they were intended, namely for a coastal current parallel to the beach line. Precisely in this, however, the abnormal destructions and evasions will have to be sought, which did not appear at any other point of the coast.

Hiddensee Island:

The island of Hiddensee has a breakthrough south of the village of Plogshagen, and the passage is structured by 2 coupirs of submerged fascines installed at about 2.5 metres below mean water.

One of the winged structures made of piles near the coupirung is destroyed. The coupirung itself has not suffered and even after this flood considerable siltations are perceptible, while within the coupirung the water level decreases rather than deepens.

District of Schleswig

The stone groynes at Bülkerhuck, Figure 17, are to be considered as shore protection structures first. These were built in 1870/71 to protect the very exposed lighthouse. There are seven of them, of which the end groynes VI and VII rise in the line of their crest from the mean water level to the former terrain height of the high bank, i.e. up to 2.15 metres, while groynes I to V lie at the height of the daily water with their roots in the foreshore and extend only to the foot of the former high bank.

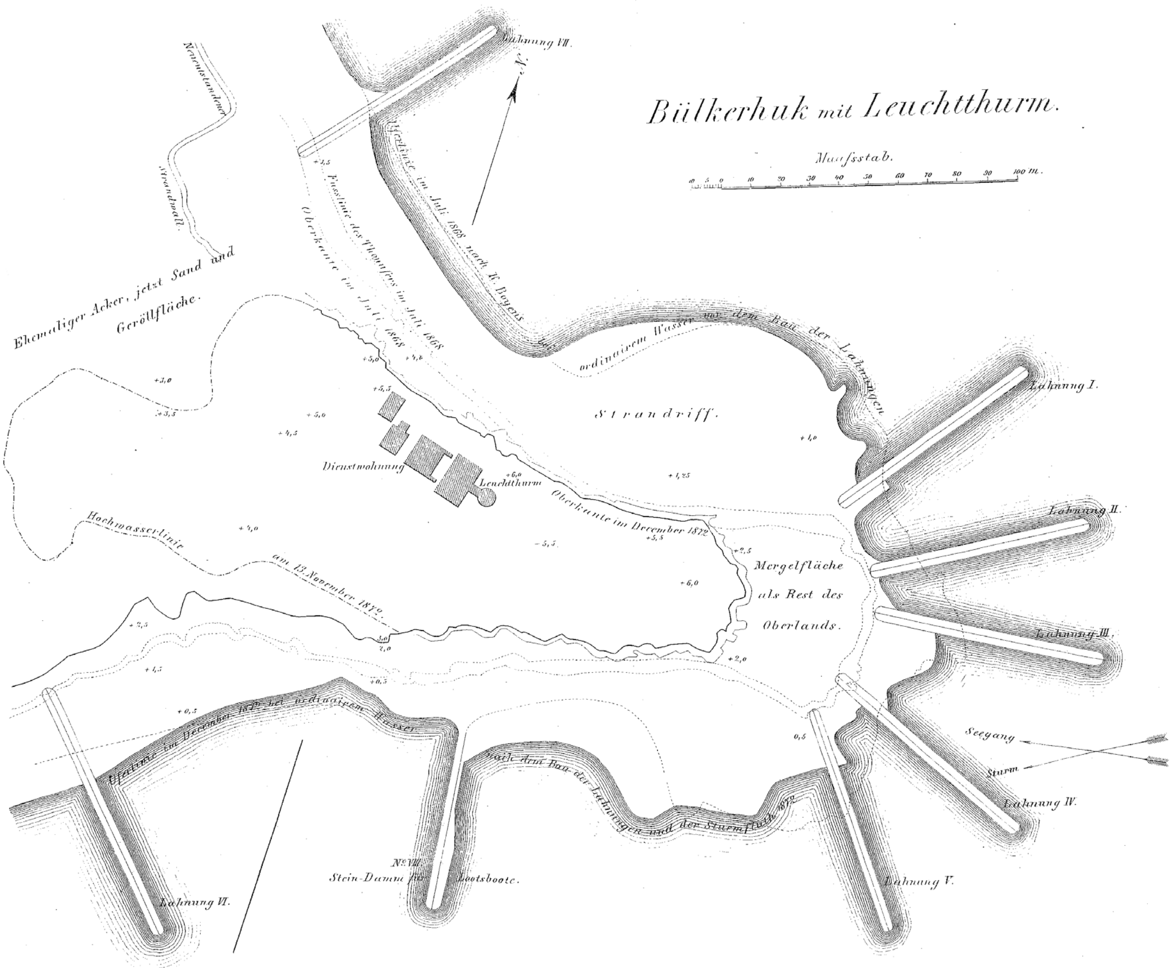

Figure 17: Bülkerhuck with Lighthouse.

The resistance of the groynes has shown that the 6 small ones have not given protection against the break-off. Groynes No. VI and VII have not had a particularly recognizable favourable effect either; the latter, however, does not seem to have been without any influence on the deposition of the broken-off material. On the other hand, a stone embankment No. VIII, which has been in place for some time, has contributed to the collection of the washed away soil.

The groynes are constructed as stone embankments, which are piled against a double pile wall and paved with 1½ -fold side slopes. The large groynes have held up very well during this storm surge, only in the upper part of them some stones have been displaced, others have fallen out. The smaller groynes, which lie horizontally from the shoreline to the head, have, with regard to the shallow beach next to the pile wall, only small stones throughout, which are more or less thrown apart by the swell and have not been spared even on the most recent occasion. The fact that these light structures have not suffered more is probably due to their low position, as a result of which they have been 3 metres deep under water.

6.2.2 Stone Works and Stone Revetments

District of Szczecin (Stettin)
The stone revetment at the foot of the clay bank of Groß-Horst held up well, but because of its low position it could not prevent the clay bank from being washed away.

District of Stralsund
Island of Hiddensee:

The stone groynes at Dornbusch have held up quite well on the whole, and considerable siltation has even occurred in some places. On the other hand, the shore between two stone structures has collapsed and one stone structure has been almost completely smashed and sanded in, so the high shore has been attacked.

Wittow Post House:

The shore structures, stone groynes and catch fences have on the whole performed well.

Arcona and Vitte on Wittow:

The seawall on the high shore at Arcona, which consisted of a stone revetment resting on the bare chalk shore and supported against a row of piles at the foot, was swept from both ends on the evening of November 12th and overtaken by the surf from 3 to 10 a.m. on November 13th. As a result, the stone revetment was washed away, especially in the upper part, and the stones were thrown down and driven away by the swell. As a result, about half of the stone cover was completely destroyed, a further quarter of it was badly damaged, and the remaining parts were more or less loosened. The stone structures placed in front of the shore suffered less, probably because in their deeper position the attack on them by the swell was of lesser intensity. Only three of the revetments were severely damaged and almost completely destroyed while the others held up quite well.

The lining walls built in front of the clayey shore near the village of Vitte were churned up from the north side by a northerly current on the evening of November 12th and later completely destroyed by the surf passing over their upper edge, the stones being swept away by the sea. The walls were built almost plumb and dry without mortar.

Ruden Island:

The revetments on the northeastern beach have been preserved fairly well, while those on the eastern beach have been more or less damaged by the tearing out of stones. In general, these structures are separated from the sandy beach at the roots, and since they usually consist only of smaller stones resting between strongly constructed wattle fences, these stones have been thrown out and some of them deposited close by.

Thiessow:

At the southern tip of Rugen (Rügen) on Mönchgut, a section of stone works has been constructed, consisting of larger stones, which also rest between strong wattle fences, as on Rugen (Rügen), but have been more carefully paved in the crown. The same had so far offered good resistance. They lie with the top at mid-water level, with the root at l.6 metres above mid-water and the crown has a slope of 1:20. The same had caused the large sand beach to widen and provided good shore protection.

At high tide, however, the clay shore has been reached, washed away and the groynes have all been detached at the root. The stone structures most exposed to the wave action were destroyed by throwing out the stones, which were deposited on the seaward side of the structures by the storm. On the Holstein coasts, where a tightly closed pile wall forms the enclosure in place of the wattle fences, against which the packing is inserted with great strength, the stones have rarely been thrown out.

Greifswalder Oie:

Of the revetments built here, all have suffered to a greater or lesser extent and are in need of repair. The one located to the east has suffered the most, breaking open at about 45" or 14.1 metres, and its stones have been swept away by the sea.

District of Schleswig

The stone coverings made for the protection of shore stretches or at road embankments etc. have – apart from the protective covering at Haddebyer Damm, vis-à-vis Schleswig, which was made of irregular stones without gravel bedding - not suffered at all by the direct wave impact, but have remained intact, no matter whether with flat or with steep construction, if the terrain behind the same or the crest is not washed out. Where the crest was washed out, the stones were thrown backwards.

The most magnificent picture of such destruction is provided by the stone cover in front of the Grand Ducal Oldenburg village of Niendorf, northwest of Travemuende (Travemünde), in the Neustadt Bay, and therefore a description of this devastation may follow: "The now destroyed 460-metre stone deck was constructed at Niendorfer Strande in 1869. Since the floods of the previous years had repeatedly destroyed the shore protection there, this construction was carried out only after careful consideration. The slab formed a circular arc of 6.3 metres radius in the transverse profile, which belonged to a circular section of 0.43 meters height, which rested with the hollow side upwards on a 1½ fold sloped embankment and was extended downwards to such an extent that the total arch height was 6.9 metres. The slope was 3.72 metres long.

The crest was 3.72 metres, the foot 0.29 metres above mean water and the footpath paved along the crest of l.72 metres width had a 0.07 metres drop inland. The stone cover was bedded in gravel, which was separated from the underlying sand by a 0.14 metres thick layer of clay. The gravel contained aggregate stones up to 10 lbs. in weight. The minimum dimensions of the revetment stones were 0.43 metres in height and a minimum weight of 200 lbs. The stones were well fitted together and carefully interlocked from below with wedge-shaped pieces of stone so that the returning wave could not throw a grand out of the joints. In the course of time the slope had been covered with sand up to half its height and was in an intact condition when this storm tide came in.

At 6 p.m. on November 12th, when the water was 1.5 metres above mean water, the first splash waves passed over the stone revetment, and it was not discernibly damaged until 4 in the morning of November 13th. Later the stone cover lost the upper half. It broke only when the water, rising higher in the meantime, washed away the sand on the back of the ridge. Of course, it must have been easy to tear off the stones from the top layer by layer. Stones weighing more than 1000 lbs. have been flung away by the water, and all broken off stones lie inland".

In contrast, the stone embankment at the "Großer Gottorfer Damm" near Schleswig, made of rough stones on a gravelbed, has held up, although this embankment was submerged to a height of 1.3 metres and was broken from the inside in 4 places, but fortunately always in such a way that the outer, well-fortified bank against which the embankment leaned was preserved.

Similar conditions in one direction or another have also been seen elsewhere, e.g. at Eckernförde, Apenrade, etc.

It can therefore be regarded as established that slabs made of rough stones over clay banks with a twofold or one-and-a-half fold slope and bedded on gravel resist wave action excellently as long as their crest is not flooded, and that they still prove their worth in the event of complete flooding if the crest of the embankment is not washed out, but that they are lost if the crest is washed away or breaks, since the upper edge of the slope thus loses its hold.

In the construction of such slabs, therefore, the aim must be to keep the crest free of water or, if this cannot be done, to make it as resistant as possible to the attacks of the sea.

6.2.3 Dikes and Dams

District of Szczecin (Stettin)

The fascines embankment in Swinoujscie (Swinemünde) in the fortress moat between the lighthouse and the eastern pier has been completely destroyed and this passage has been restored by an emergency bridge.

The embankment on the left bank of the river Swine, from the construction yard to the pilot station, has been severely damaged by overflowing along its entire length.

The road embankment between Bannemin and Hammelstall was severely damaged by the flood. The residents of Hammelstall had punctured the dam to give the water a faster outflow into the backwater.

District of Stralsund

Zingst Island:

The sea dikes on Zingst have suffered considerably from the flooding as well as from the receding water, and the dike has been destroyed over an average of 1/8 of its length; deep scouring has also occurred in many cases.

The inland dikes near Zingst have suffered less, showing only insignificant damage, at least as far as their bodies are concerned. In contrast, the inland dike at Müggenburg, especially in front of the old Straminke, has suffered considerable damage. The nature of the destruction will be discussed in more detail here. The sea dike was located about 95 metres from the water line, was 2 metres high above mean water, had 2-fold inner and 3-fold outer slope. The only material present was dune sand, which was covered with 0.13 metres thick turf and showed dense scarring.

As long as the flood did not exceed the dike crest, the dikes, despite their light construction with a crest width of 1.25 metres, held their own. With the flood, however, the crown and inland embankment were destroyed and the fall of the dike began. Since the dike had provided a convenient footpath for passers-by on its crown, the turf on it had died in many cases, and it was mainly these points where the flooding caused the first destruction, while whole stretches of the dike remained well preserved, as the rapidly growing inland water level in the floodplain moderated the attacks of the overflow on these stretches.

Since the breaching of the sea dike occurred mainly in front of the village of Zingst, the main current passed through the village itself, accompanied by strong seas, and caused the most considerable destruction to the dwellings here. The incoming current, which mainly had to fill the large inland basins, emerged with great force in the resulting strong inland gradient, and the water level curve in Figure 12 for Barth shows the rapid growth of the inland water when the height of 2 metres above mean water was exceeded by the tide. As a result, the inland basins reached a water level of 2.83 metres. The water level curve in Figure 13 for Barhöft also shows the rapid fall of the tide, while the same curve for Barth shows the opposite phenomenon. According to the situation, the curve of falling tide at Barth remained dependent on 2 discharges. Once the water at Barhöft had to go into the sea, at the same time it could find its outflow over the low peninsula of Zingst to the sea. However, the latter flow could not act sufficiently and so the falling curve at Barth is seen to decrease only slowly. This lowering decreases even more when the tide in the inland hedges had receded to l.5 metres above mean water and it found only the outflow at Barhöft open, the peninsula lying at about 1.5 metres above mean water. The strong current running back across the peninsula to the sea, however, brought new very disadvantageous destruction in its wake, because not only was the whole foreshore denuded of sand, which was thrown to the sea, so that the whole foreshore showed almost only the bare turf of the subsoil, but also the edge of the green land broke off and those edges, which lay particularly low, finally had to take up alone the current, which the deeper subsidences concentrated on these places. As a result, deep watercourses were formed, into which large lawns hung, and these watercourses were cut deep into the inland. With this outgoing stream, therefore, a complete destruction of the foreshore and the adjoining meadow areas had occurred, while on the latter, still further inland, lay large sandy areas which the incoming stream had carried inward from the dunes as the tide grew.

Exactly the same phenomenon in all details had also occurred on the Fischland south of Wusterow. These destructions were a reason to restore the embankment not only for the protection of the villages and lands, but also to extend the whole length of this peninsula in order to obtain a good foreshore, so that the incoming and outgoing currents would be blocked and the effect of the beach constructions would be secured.

Wolgast. These weak dikes along the Peene River for the protection of the properties behind them have suffered greatly from the overtopping water and have sunk very much.

Wiek near Greifswald. The dikes enclosing the Rykflufs are flooded and have suffered multiple breaches as a result of this and the backflow of the water.

District of Schleswig

The dikes built on the Baltic Sea coasts in front of the lowlands were closely connected with the dune, and the district of Oldenburg in particular had such larger structures, which were almost without exception destroyed by the storm surge.

In front of Lake Gruber, a dike was located on the dune-like beach ridge, which was filled with sand, was 3.8 metres above the daily water level of the Baltic Sea determined there, had a crown width of 3.9 metres and a twice sealed inland dike, as well as a four times sealed outer dike, up to 2.2 metres above mean water, from where the embankment joined the existing beach profile.

The crown and the upper part of the outer embankment were covered with beach grasses, the lower part of the outer embankment and the beach, up to about 3 meters from the base of the dike, were protected by a layer of boulders, which had a thickness of 0.3 metres in the angle of connection, and levelled out both downwards towards the beach and upwards to the middle of the outer embankment. The outer beach was planted with marram up to a height of about 1" above mean water.

The dike in front of the Klostersee lake, also a sand dike on the beach ridge, had somewhat weaker dimensions, 3.44 metres crown width, 3.44 metres height above zero and a four times sealed outer dike and a twice sealed inner dike.

The dike in front of the Klostersee was completely destroyed by the storm tide at 6 a.m. on November 13th, the one in front of the Gruber See at 7 a.m., to such an extent that the place where the latter had stood can hardly be found anymore.

The highest level of the Baltic Sea was marked by the engineer Bong-Schmidt at 2:30 p.m. with 3.2 metres above mean water.

The height measurement agrees very closely with the Kiel observation. One will therefore come close enough to the truth if one also assumes agreement for the morning times of November 13th, but takes into account that–- because the highest water level in Neustadt Bay occurred one level earlier than in Kiel Bay–- the earlier, coinciding water levels off Gruber and Klostersee Lowlands may also have occurred about one hour earlier than in Kiel.

According to the observations of the Imperial Shipyard in Kiel, taking into account that the water level observed there at 7 or 8 a.m. already occurred at 6 or 7 a.m. in the Neustädter Bucht, the water here was:

	6 a.m.		2.15 metres	above	zero,
-	7 a.m.	-	2.88 metres	-	-

Therefore, these dikes of the Klostersee and of the Gruber See were already destroyed, when the crowns of them were still respectively 3.44–- 2.15 = 1.29 metres and 3.80–- 2.89 = 1.47 metres high above the early level of the Baltic Sea.

Therefore it is to be stated for these dikes that the rapid destruction of the same, even at a water level which at the Grubersee dike was still completely within the vault covering of the sluices, is to be regarded only as an effect of the swell on the loose sand and sod material of the four fold sloped outer dike embankment.

This fact is confirmed by the observations made on the spot, namely by the perception of inhabitants of the village of Dahme, who were still able to walk on the dike crest on the morning of November 13tth and noticed how the outer dike embankment was completely washed away and the dike therefore only formed a perpendicular wall against the attacks of the sea.

Some of the dikes on the island of Fehmarn were still under construction. They, as far as they were built of sand and rubble, have also without exception been almost completely torn away, while the dikes built of cohesive material and clay, despite inadequate embankment, are partially preserved.

A description of their construction and the nature of their destruction may be omitted here, since these dikes have almost all been attacked by the water entering in open places from the inside, i.e. from a side which was not equipped to resist the sea state.

The Barsbeck dike, in front of a part of the Probsteier salt marshes, does not consist of sand, but of binding dike soil. It is directed approximately from south to north, its outer slope does not face easterly winds, and thus did not have to withstand such a strong swell during the storm surge as the dikes in the Oldenburg district. The dike has a length of 2.2 km, an average height of 2.39 metres, and a lowest height of 2.02 metres above Kiel zero. It is therefore lower than the Gruber and Klostersee dikes.

Furthermore, the dike has an average crown width of about 2 metres and a sealed slope, with outwardly 3 to 4 fold, inwardly 2 fold the height of the dike.

Between 9 and 10 a.m., when the water passed over the low dike, foundations failed in some places due to insufficient stocking. A significant difference between this damage and the complete destruction of the Oldenburg dikes can be found in the fact that the Barsbeck dike, although having fractures, remained repairable as a dike, while the other dikes disappeared completely up to a certain height.

This circumstance can only be attributed to the more resistant material and it has been confirmed here that the clay dikes are able to resist the attacks of the sea with success, while the sand dikes are incomparably less resistant, an experience which is already known, but whose value becomes illusory where no materials other than sand are available and where therefore only flat embankments can form a supplement for the resistance.

This experience has also been made on dams exposed to storm surge.

The Eckernförde Bay offers the richest resource in this respect, and in view of the interest aroused by the particularly hard-hit town of Eckernförde, it is permissible to dwell here and start by providing a description of the terrain before shedding light on the extent of the destruction.

The western end of the Eckernförde Bay is formed by the town of Eckernförde and the causeway from here to Kiel.

The town of Eckernförde is located on a peninsula, which rises 3.2 metres above the mean water level of the Baltic Sea at its highest point. This peninsula separates the Windebyer Noor (Lagoon) from the Eckernförder Bay. North of the town there is a harbour about 80 metres wide, which used to connect the lagoon with the bay. This connection was cut off in 1856 by the construction of a dam through the harbour, so that the high water levels of the bay could no longer affect the lagoon and drainage of the lagoon into the harbour only took place through a lock that closes when the outer water level rises.

Both the dams just described and the causeway to Kiel were destroyed.

The dam, about 7 meters wide, was made of sand and its crown was about 2 metres above mean water level; the roadway was paved and the shoulder had been reinforced by tar-concrete. On the harbour side, a retaining wall of granite on sill grate had been built at mean water level above fascine packing, originally so high that the top of the wall fell into the edge of the subgrade.

A lowering of the fascines had necessitated the later construction of an earth embankment above the wall, which was well scarred at the time of the storm surge. The front embankment had a 2-fold slope and was secured at the foot with a stone fill.

On the evening of November 12th, water seepage was noticed on one side of the embankment. At 8 a.m. of November 13th the first break-offs occurred on the dam, and after 1.5 hours it disappeared completely. On November 18th, at the place where the dam had stood, the water level was 2.8 metres below zero.

At 8 a.m. in the morning of November 13th, the water in the harbour of Kiel reached a depth of 2.8 metres, and since similar conditions prevailed in the harbour of Eckernförde, it may be assumed that the dam was flooded around this time and broke as a result. This is confirmed by the statements of eyewitnesses.

The causeway leading through the meadows in front of the Goossee etc. along the beach at the Eckemförder Bay to Kiel was filled with sand and provided with clay embankments, which were placed on the flat sandy foreshore.

The height of the dam was 3.3 metres above mean water level. The dam was not flooded, but the 3 breakthroughs were caused by the swell. On long stretches, the clay embankment on the seaward side is still standing, while the rest of the road has disappeared.

The breakthroughs have occurred at those places where descents led to the beach, and as a result the protective clay cover and the grass surface were interrupted. This is clear evidence of the value of clay over sand and the caution required when providing descents from dikes and dams. It should also be mentioned here that in the case of overflowing, a macadam surface is preferable to a pavement, since it also offers a better guarantee against destruction due to its impermeability.

An enumeration of all further destructions observed at dams and dikes would only tire and it is already clear after the phenomena mentioned here that care must be exercised in the choice of the material to be used for dam constructions, which are to resist either the swell or the overflowing water, and–- if clay is too difficult to procure for filling–- the sand body should be provided with clay embankments in any case, if stone revetments cannot be envisaged either.

6.3 Port and Shipping Structures

6.3.1 Port Entrances

District of Gdansk (Danzig)
There were no adverse effects of the storm tide on the harbour structures at Nowy Port (Neufahrwasser).

District of Szczecin (Stettin)
The pile works (advanced works or the head of the eastern pier) in Swinoujscie (Swinemünde) held up very well on the whole. Some concrete blocks in the same, which load the stone pack, have shifted; one block is shattered; one strut is broken, and 2 piles on the seaward side have broken off under the breast bar. Some of the filler stones between the concrete blocks have been thrown out.

The blocks, which were kept in stock on the breastwall and the top of the pier, have been thrown down by the breaking waves and were deposited on the harbour-side slope of the pier. Immediately adjacent to the small lighthouse, the pavement of the breakwater has been ripped open. The top layer of the breast wall is damaged in several places by the large stones thrown up from the seaward side; the paving over the breakwater has been lifted off in a few places; the two short outer banks made this year have been destroyed; on the seaward stone throw, from the beacon to the old pier head, many shifts and changes against the former condition are apparent. However, these damages have not grown to a dangerous extent.

A very large quantity of stones has been thrown from the sea over the wall into the harbour. When clearing up the gap created in the stone body of the eastern breakwater next to the light beacon, large cavities were revealed under the uppermost thick layer of pavement, which is supported in an arch shape against the foundations of the breast wall on the one hand and the light beacon on the other.

District of Schleswig

Here only the harbour buildings of Schleimünde are to be remembered.

That the attack of the sea here has been a very powerful one is already evident from the foregoing, but nevertheless only the unfinished work on the newly built northern breakwater has suffered damage, while on the other hand the head of the old southern breakwater, which is still awaiting reconstruction, has been completely shaved with the beacon, and all the provisional structures, as well as the old pilot establishment, have been completely destroyed. The new breakwater is enclosed in the upper masonry by 2 retaining walls, of which the seaward one, which supports the 1.15 metre high parapet with its upper edge 3.44 metre above mean water level, is constructed according to Emy's profile.

The inner wall is 2.58 metres high above mean water and stands at such a distance from the first that the pier without the parapet is 3.44 metres wide. The space in between, as far as the structure is touched by water on both sides, is filled with scree, landward with pure sea sand and paved in the upper course.

At the head, the pier widens circularly to a diameter of 7.8 metres between the parapets and the profile here shows Emy's curve all around. On the centre of the pier head stands the lighthouse.

The base of the concave wall is protected by a masonry embankment sloping from 0.8 metre above mean water in a triple arrangement to 0.8 metre below mean water, which is supported along the pier by foot piles, but should be secured in front of the head by large masonry concrete blocks.

On these constructions, for which only granite was used as stone material, damage occurred only in so far as they were unfinished or had been executed so recently that the cement had not been able to harden sufficiently. These have affected only the masonry embankment and the concrete blocks. The latter, which were ready to be toppled and were placed on tipping frames at a height of 0.8 metres, were completely destroyed. The sea had overturned them on November 12th, but they had not visibly suffered any significant damage. On November 14th, only small chunks of the blocks were left. Since the breakage occurred only in the mortar joint, the insufficient quality of the mortar, or in any case the too early exposure of the blocks to the waves, is responsible for this. The blocks were no more than 4 weeks old, some only a few days, and the mortar was not very strong.

On the stretch where the paving of the breakwater is over sand, it has caved in, proving that under the upwelling of the water between the walls, part of the sand has been washed out.

On the section filled with rubble, no such subsidence has occurred, but here the cement painted into the joints of the paving stones has been thrown out in many cases. This phenomenon can only be explained by the fact that here, too, water has entered between the walls from below, forcing the air in the interstices of the rubble under the cover and compressing it to a tension sufficient to break the cement and allow the air to escape through the resulting opening.

6.3.2 Wooden and Stone Quay Walls

District of Coeslin (Cöslin)

At the port of Colbergemünde, the backfill behind the wooden walls sank in some places.

In the port of Stolpmünde, the backfill soil of the piles has been washed out in some places. This has occurred in particular at the final piling of the outer harbour, where the waves have even penetrated some of the three-inch planking.

District of Stralsund

A new pier has partially lost its revetments due to the impact of vessels.

The older piles and quay walls have been washed out and the cladding destroyed. The iron balm quay wall has suffered major damage from the impact of large seagoing vessels.

The deck plates protruding about 0.16 metre in front have been detached almost everywhere, and a part of them together with the upper part of the masonry has fallen into the harbour.

The protrusions of such deck plates should be avoided everywhere where waves attack.

District of Schleswig

The devastations observed on piles and quay walls are limited almost everywhere to a few easily removable backwashes and insignificant damage. More important are only the destructions in Eckernförde, which provide interesting comparisons.

The deepening of the harbour in Eckernförde, already mentioned above, led to the collapse of the part of the quay wall built a few years ago, which was founded on concrete but only at a depth of about 1 metre below mean water level. Another part of the wall, which is still under construction and whose foundations consist of a sill grate placed 3 metre below mid-water, has been preserved. The old wooden piling has also been washed free, the waves have partly torn off the back covering, but the piles and anchors are still standing.

6.3.3 Landing Stages, etc.

District of Coeslin (Cöslin)

In the harbour at Golbergermünde, forty to fifty planks of the gangways and unloading bridges have been loosened and drifted away.

District of Stralsund

The wrought-iron swing bridge has suffered some damage to the fore-legs and has had to be readjusted.

The major part, which can be considered as the total damage of the destroyed port buildings, requires the restoration of the steamship landing bridge for the ferry traffic to Rugen (Rügen). This bridge was constructed of wood, without infill, with its forward end 0.92 metre above mean sea level. It lost its planking due to the uplift of the water and wave action.

The total destruction happened suddenly when the steamship "Hertha", pushed by another ship, ran into the bridge and cut the planking. The "Hertha" was carried further with the decking attached to the ship on both sides to the filled ramp (ferry hatch) about 30 metres away, on which it remained lying with the decking.

Barth. Of the harbour structures, this storm surge almost completely destroyed the large loading bridge 60 feet long and 30 feet wide; a smaller bridge 30 feet long and 16 feet wide was completely destroyed.

6.3.4 Lighthouses

District of Szczecin (Stettin)
The oscillations of the lighthouse at Gr. Horst were so significant during the hurricane that the rotating device momentarily stood still, but then resumed a faster movement.

District of Schleswig
No further damage was done to the lighthouse at Schleimünde, except that the shutters of the window on the lowest floor broke and, as a result, this window also broke, putting the basement and first floor under water.

The lighthouse built on the very exposed Friedrichsort sand reef in Kiel Bay in 1866 also suffered little. However, as in the past, a settling of the cement-lined stone cone by about 3 centimetres, as well as a deviation of the cone from the tower wall by about 2 centimetres on the north side, became noticeable, as well as some cracks in the joints of the stone cone. The reason for this can be found in the construction of the building.

The tower itself is built of bricks on a pile grid, 5.5 metres in diameter. In order to create an outer foot slope, a 2-meter-wide fascine ring was first laid around the tower in a diameter of about 17 metres, up to a height of 0.4 metres above mean water level, and the inner space, gradually rising towards the tower, was filled with gravel. The base outside the fascine ring is a twofold slope made of coarse stones, and the upper layer of the fascines is covered with stones in the form of slabs. On the cone, which is filled with gravel, a layer of bricks is placed with stones, and these are covered with large boulders. The latter, as well as the stones of the lower slab first placed at the base of the cone, are grouted with cement.

The fact that the slab situated at mean water level, made of rather light stones, suffered little is due to the rapid rise of the water. Nevertheless, the settling of the stone cone is partly explained by the fact that the base of the grouted cone only has the above-mentioned slab for support, and partly by the fact that the inner gravel core will have been somewhat washed out under the buoyancy of the water through the fascines and thus caused to sink.

6.3.5 Navigation Marks

District of Szczecin (Stettin)
The bell buoys and two buoys from the harbour entrance to Swinoujscie (Swinemünde) drifted onto the beach at Ahlbeck; the remaining harbour buoys were recovered at Möwenhaken.

District of Schleswig
Of the large buoy beacons only one, the one on the middle ground of the Eckernförde Bay, was driven away and stranded to the southwest of it.

It lay at 4 fathoms water depth in front of a stone of about 1000 pounds weight and in front of 12 fathoms of 1.125 inch chain, of which about 3 fathoms were shackled for better balancing of the buoy. The blame for this buoy being displaced is probably borne by the following circumstances: the stone lay on a firm clay foundation, in which it could not sink; the buoy had its place at the extreme western edge of the plate, from where the terrain drops off abruptly to greater depths; also, the beacon offers a strong wind trap and there will have been violent shocks during the heavy seas. Instead of shackling, this buoy has now received increased load weight and is now ahead of 12 fathoms of chain.

All the pointed buoys have maintained their places, even the most awkwardly situated one on Klaverberg, 0.375 miles from Bülkerhuck. These buoys lie continuously off 6 fathoms of chain, half 1 inch, half 0.625 inch thick, on a stone weighing about 500 pounds on 3 fathoms of water.

The small buoys in the Schlei, on the other hand, have not been able to withstand the tearing current coming in and going out, since they were anchored with considerably less weight.

The accidents in the villages on the coast were not the subject of this publication, which only had the technical part of the whole flood phenomenon as its purpose.

However, it should not remain unmentioned that a small brochure, titled: "Die Sturmfluth vom 13. November 1872, Glückstadt 1873", gives a very detailed account of this subject for the province of Schleswig-Holstein.

7 Annex: Historic (non-metric) units of measurement

Fundamental to the idea of weights and measures are the concepts of uniformity, units, and standards. The historical development of units was generally through trade and conquest. Even though the idea of units caught on quickly over wide areas, they differed regionally, which implies some uncertainty into recalculation into modern systems.

Historically, two types of measurement systems can be distinguished into evolutionary systems, which developed more or less out of habits, and planned systems, such as the International System of Units (SI; Système Internationale d'Unités), used by the worldwide scientific community and most nations. In the following uncommon, ancient units are explained.

Length and surface dimensions

Measurements of length in many parts of the world were once commonly made in miles, yards, feet and inches. Depending on the region, however, these units varied in definition, e.g. a foot usually equaled 28 to 32 cm, in extreme cases also 25 and 34 cm. The Law of December 10th, 1799 stated that one metre is equal to exactly 443.296 French lines, the units being the Paris line: 1 line = 1/12 inch = 1/144 feet. It was not until 1875 that the metric system was established as the international base unit for length. However, even today, old units of measurement are still in use in some areas of Anglo-America.

For conversion purposes, these are currently defined as follows:

1 mile ≙ 1760 yards ≙ 5280 feet ≙ 63.360 inches
inch ["]/[in]: 1"≙ 2,54 cm
English foot [']/[ft]: 1' ≙ 12" ≙ 30,48 cm
Prussian inch ≙ 2,615 cm (used by Baensch)
Prussian foot ≙ 31,3854 cm (used by Baensch)
yard [yd]: 1 yd ≙ 3' ≙ 0,9144 m

mile [mile]: 1 mile ≙ 1609,344 m

Surface dimensions were made in square feet or acres. One acre was once defined out of habit as area, that can be ploughed in one day with one ox. Acres are still used to describe large areas in the US. Today one acre is equal to 4047 m^3.

Air temperature

As a unit of measurement for temperature, the Réaumur (R) scale, introduced in 1730 by R.A. Ferchault de Réaumur, used to be common until the beginning of the 20^{th} century. It is defined as the interval between the boiling point of water at normal atmospheric pressure (80 °R) and the melting point of ice (0 °R) divided into 80 equidistant parts (Réaumur degrees; symbol: °R/°Ré). Accordingly, a temperature difference of 1 °C corresponds to a temperature difference of 4/5 °R.

Atmospheric pressure

Atmospheric pressure used to be measured by mercury barometers. The height of the mercury column was mostly given in feet, inch or Paris lines. According to the above-described dimensions of length, the sizes varied regionally. Since the height of the mercury column depends on the temperature and the gravitational acceleration at the measurement location, it has to bes reduced to 0 °C and normal gravity in sea level at 45 ° latitude for comparison purposes. Later the height of the mercury column was given in mm Hg and Torr where 1 mm Hg corresponds to 1.332 mbar. On June 1^{st}, 1975 the atmospheric pressure started being expressed in hectopascals (hPa) with 1 hPa equals 1 mbar. (The air pressure data used by Baensch for the analysis of the isobars were not reduced to sea level.)