ence of some factor or other, as the concentration, the temperature, on the course of the process.

MADSEN & NYMAN and also Miss CHICK derive from their observations that the influence of the above factors may likewise be expressed in formulas. Thus the well-known formula of ARRHENIUS in which the relation between temperature and velocity of reaction is expressed, would also hold good in this connection. It seems to me, for reasons already mentioned, to be prudent not to follow them on this path. Therefore we refer, with regard to the points meant, to the figures 2 and 3, without commenting on the subject.

Geology. — *"On a long-period Variation in the Height of the Ground-water in the Dunes of Holland."* By Prof. EUG. DUBOIS. (Communicated by Dr. J. P. VAN DER STOK).

Unmistakable and obvious is the lowering that the height of the ground-water in the dunes of the provinces of North- and South-Holland has undergone in consequence of the lowering of the level of the water at their east border (the making dry of the Lake of Harlem and of a large part of the IJ) and of deep cuttings in the dunes themselves (North-Sea Canal), furtheron, not less, by the collecting of large quantities of water supplies for some cities and towns.

From these causes there resulted a lowering which may be called a permanent one, inasmuch that soon they have brought about a new state of equilibrium with the supply by the part of rainfall which soaks in, and the flowing off. This really did take place in each case in which certain limits were not transgressed and as long as the collecting of water did not increase.

Side by side with these artificial changes of the height of the ground-water in the dunes, there exist also changes by natural, viz. climatal causes. These, in this as in other cases, are not continuous, but they do occur in periods. Indeed, in the latest historical past, as far as data are available, very clearly dry and wet epochs alternate with one another.

The Commission which, in 1891, inquired in the supplying of water from the dunes to Amsterdam pointed out, in their report, that from 1849 till 1856 there was a period of much rain, from 1856 till 1868 a dry period, again followed by the rainy years of 1869 till 1882. They showed also (for Utrecht) that under the combined influence of rainfall and evaporation such wet and dry epochs are

found, with maxima about 1855—56 and 1882—1883 and a minimum about 1869—70.

In his "Hyetography of the Netherlands" Mr. ENGELENBURG [1]) inquires if there exists any relation between sunspots and rainfall. He finds that we can admit that such a relation, if it exists at all, does not appear very distinctly.

It is the merit of Dr. LAURENS VUYCK, in his elaborate treatise on the vegetation of the dunes, [2]) to have submitted the problem of the change of height of the ground-water in the dunes, as it also appears from older writings, to a close investigation. He however thinks of a progressive drying up of the low places in the dunes, having slowly taken place from as long ago as the end of the eighteenth century. From a careful consideration of the problem he arrives at the conclusion that the cause can only be found in a continuous and imperceptibly slow filling up of those low places with eolian sand.

The earliest intimation of the dunes drying out, which ought once more to be quoted, is from the end of the 18th century. In the report of a committee from that time to the Government, the reporter, JAN KOPS [3]) makes mention of the fact, that at the time of his inquiry, in 1797, the obstacle to the culture of the dunes arising from an excess of ground-water has been removed for a great deal. "In all our inspections, in the North as well as in the South, the most experienced people told us unanimously that during the last ten years, from year to year, less and less water than before is found in the plains amidst the dunes. They showed us places which formerly stood two or three feet under water and became extensive icefields for winter-sport, but now were only somewhat muddy in winter. In other plains, only four years ago, there stood still water in spring, from which nothing now is to be seen, and so it is with almost all the dunes. This particularity has raised our highest attention and surprise, as on account of the well known and alarming rising of the level of our rivers and inland water, we should expect the sinking down of the water of the dunes to be checked and prevented by it. Nobody was able to explicate to what cause this decrease of the dune-water should be imputed and we too could not trace out the true cause of it. But where it is to be sought for, this circumstance is most favourable for all following undertakings in the dunes." (p. 114 and 115).

[1]) Physical Transactions of the Kon. Akad. v. Wet. Amsterdam 1891.

[2]) LAURENS VUYCK, De plantengroei der duinen, Leiden, 1898.

[3]) Rapport van de Commissie van Superintendentie over het onderzoek der Duinen van het voormaalig Hollandsch Gewest. Leiden 1798/99.

So it cannot astonish us that in 1805 A. P. TWENT [1]) makes mention of great dryness, making the birches in the plains amidst the dunes die at the tops, and that for three years there had been no water in places where in earlier times it always had been found, even in summer. "Considering that the sea does not be lower now than before, as shown by all circumstances, of which not the least certain is that the outlets of the inland waters are not improved in this part, this matter deserves double consideration by the naturalists".

In 1816 and still in 1823 a quite different state of things prevailed, as appears from the prize-essay on the making accessible of the valleys in the dunes along the coast of Holland by D. T. GEVERS, [2]) an answer to the question: where and how to drain the water from the plains in the dunes and at the same time facilitate the access to them, in order that they may no longer lie useless and uncultivated. This, namely, was imputed for the most part to the want of the necessary evacuation of the water. This inconvenience then was very great, and its removing indeed was the chief purpose of the large treatise.

Concerning a following dry period in the dunes no direct information has come to my knowledge. It appears however that from 1831 till 1840 the rainfall at Zwanenburg (Halfweg), that is very near the dunes, has been considerably below the average. [3])

Certainly the level of the ground-water in the dunes of the communes of Zandvoort, Bloemendaal and Velzen, as well as in the dunes of the province of South-Holland (cf. VUYCK, l. c. p. 184) was very high about 1845, so that for instance people skated in the dune-plains near Zandvoort.

On the contrary, about 1860, the ground-water in the dunes stood only little higher than in the present period which is get very dry; the water holes which contain now but little water were sufficiently but not abundantly provided. Though after 1858 the water supplies to Amsterdam, from the dunes, became less than in the former years and remained so till 1864, yet it was necessary to make new water collecting canals.

Then again follows a wet period, during which many plains and lower places in the dunes became marshy or were drowned in winter, frequented by a number of waterfowl (ducks, pool-snipes) and in some spots remained occupied by water even in summer, so that water-

[1]) Wandeling naar de Zeeduinen van Wassenaar tot digt aan Scheveningen, p. 5.

[2]) D. T. GEVERS. Verhandeling over het toegangbaar maken van de duinvalleien langs de kust van Holland, uitgegeven door de Maatschappij ter bevordering van den Landbouw te Amsterdam opgericht. Deel 18, Amsterdam 1826.

[3]) Nederlandsch Meteorologisch Jaarboek voor 1878, p. 288.

plants could flourish there. And such a state of things obtained in all the dunes, outside the influence of the large water works, arriving at a maximum about 1880.

A few years later the present dry period commenced, by which, also independently of each artificial cause for a lowering of the ground-water in the dunes, its height decreased so much that in the present winter water is only found at 2 M. below the level surface of plains, which about 1880 were flooded in winter. Certainly no less than 2 to $2^1/_2$ M., in some places probably more, the ground-water is now lower, by natural causes alone, than it was in those wet years.

The periodical changes of the level of the ground-water in the dunes, thus appearing during more than a century, agree in striking conformity with the thirty-five-year period discovered by Prof. Ed. BRÜCKNER, according to which, in almost all the countries of the earth, the rainfall and the height of the water of lakes changes. Really between 1786 and 1805 a dry period occurs (for the Netherlands too this appears from the rainfall as determined at Zwanenburg). So in the beginning of the 19th century a minimum of rain and the lowest watermarks were reached. Then follows an epoch of much rain between 1806 and 1825, again a dry period from 1826 till 1840, a new period of much rain from 1841 till 1855, a dry period from 1856 till 1870, with a minimum about 1860, the latest period of much rain from 1871 till 1885, with a maximum about 1880, finally again a dry period, with a minimum about the end of the nineteenth century. A few years ago we still were in this dry half of the cycle.

Since, some years ago DR. WILLIAM J. S. LOCKYER [1]) proved, that in the amount of spotted area of the sun also, a thirty-five-year period could be traced, from 1833 till 1900, the discovery of BRÜCKNER surely has still gained in importance. On the other hand we now understand better what may be the cause of the few temporary or lasting deviations of some countries. If the better insight we now have got in the cause of the phenomenon discovered by BRÜCKNER is well adapted to increase our confidence that we have to count with it in future, we also need not suffer ourselves to be prevented from this by the deviations in question.

Lately, from the extensive study of the rainfall in Germany by Dr. G. HELLMANN [2]) and its discussion by BRÜCKNER [3]), it again appeared how in our vicinity wet and dry periods, and pretty well simultaneously with those in the dunes of Holland, alternate with one another.

[1]) Proceedings of the Royal Society. Vol. 68. (1901). p. 285—300.

[2]) Die Niederschläge in den norddeutschen Stromgebieten. 3 Bände. Berlin, 1906.

[3]) Meteorologische Zeitschrift. Wien 1906, p. 565.

RAINFALL.

Millimeters					Progressive decadal sum above or below mean decadal sum over 50 years, percents.						
Year	Maestricht	Utrecht	Helder	Leiduin	Year	River basins of North Germany	Lower basin of the Rhine in Germany	Maestricht	Utrecht	Helder	Leiduin
1849		735 3									
1850		812 3									
1851		681.2									
1852		1048.(	876.0								
1853	489 7	737.5	662.9		53/54				3		
1854	687.9	821 1	715.2		54/55				2		
1855	543.6	6 0 9	478 2		55/56	—1	2		2		
1856	517.7	760 7	651.2		56/57	—2	1		1	—4	
1857	385 8	449.4	459.1		57/58	—3	—1	—12	—5	—7	
1858	417.1	634.9	637 1		58/59	—4	—1	—13	—8	—8	
1859	508.7	677.9	569.1		59/60	—7	—5	—18	—13	—12	
1860	628 5	810 8	730 7	874 8	60/61	—9	—6	—18	—12	—9	
1861	510 0	663 1	670.3	710 7	61/62	—8	—5	—15	—11	—7	
1862	566.2	590 8	6 0.5	659.0	62/63	—3	0	—9	—8	1	
1863	434 2	524 7	632.0	588 8	63/64	—1	2	—8	—7	0	
1864	363 3	459.7	448 0	551.2	64/65	—1	1	—6	—6	2	1
1865	549.5	710.2	696.4	822 2	65/66	—2	—1	—6	—7	3	2
1866	722.3	812 6	961.4	1065.5	66/67	—3	—1	—6	—7	2	2
1867	717.4	686 1	780 8	1047.7	67/68	—2	0	—6	—3	4	7
1868	513.3	674.4	602.4	7.5.6	68/69	—3	—1	—5	—2	4	10
1869	625 5	786.9	695 7	1013.0	69/70	—2	0	—3	2	7	14
1870	583.7	741.1	791.1	904.7	70/71	0	3	0	3	5	13
1871	504 3	640 1	603.2	764 0	71/72	—1	0	—1	2	2	11
1872	607.4	878.7	785.7	1075.5	72/73	—1	1	0	4	3	10
1873	505 8	576.3	628.1	803.9	73/74	0	3	3	5	6	12
1874	481 6	784.1	641.3	817.9	74/75	1	4	2	3	6	10
1875	724.4	787.4	565.1	808.2	75/76	3	6	2	4	2	8
1876	631.8	703.7	754.0	845.8	76/77	3	6	6	6	2	10
1877	746 6	826 1	845.4	986.8	77/78	6	8	9	7	5	10
1878	711.1	733.2	827.7	923.8	78/79	7	9	11	7	4	10
1879	561.3	698.0	664.5	803.1	79/80	8	9	12	5	4	8

RAINFALL

Millimeters					Progressive decadal sum above or below mean decadal sum over 50 years, percents.						
Year	Maestricht	Utrecht	Helder	Leiduin	Year	River basins of North Germany	Lower basin of the Rhine in Germany	Maestricht	Utrecht	Helder	Leiduin
1880	602 8	770 7	536 0	790.9	80/81	7	7	10	3	5	8
1881	730.2	773 2	627.4	913 9	81/82	7	7	7	3	5	8
1882	799 0	952 6	953.3	1029.5	82/83	4	4	5	—2	1	3
1883	624 6	618.0	601 9	841 0	83/84	4	3	4	—3	—2	0
1884	568.0	607 6	585.3	682 2	84/85	3	2	7	—1	—3	0
1885	560.1	633.3	656.4	805 4	85/86	1	0	9	—1	—2	0
1886	495.9	702 3	746.4	801 1	86/87	2	1	6	—1	—2	—1
1887	614 9	473.3	601.4	634 3	87/88	—2	—4	1	—3	—5	—2
1888	660 0	668.2	597 6	667 0	88/89	—2	—5	—1	—2	—3	—4
1889	742 8	874.1	639.4	834 4	89/90	—1	—4	0	0	0	—2
1890	701.7	777.7	606.9	743.7	90/91	—2	—4	2	1	1	—2
1891	522.3	788 3	587.1	854.2	91/92	—1	—4	2	1	—1	—4
1892	506.7	750.8	771.7	916.4	92/93	0	—4	1	5	0	—3
1893	542 7	711.9	702.3	710.4	93/94	—1	—6	—2	6	1	—1
1894	633.8	747.1	847 7	848.3	94/95	—1	—6	—6	3	1	—3
1895	668 2	743.1	678 2	772 7	95/96	—1	—6	—7	2	2	—3
1896	495.9	681 4	632.1	628 4	96/97			—8	3	2	—5
1897	553 9	733.0	658.2	794.5	97/98			—7	1	0	—8
1898	468.2	724.1	651.8	791.2	98/99			—5	4	3	—6
1899	527.5	691 0	637 0	633.8	99/1900			—7	2	—1	—8
1900	630.6	724.2	704.7	767.6	1900/01			—5	2	—3	—8
1901	467.0	817.6	608.8	730.1	01/02			—1	3	—2	—6
1902	527.8	631.3	604 9	659 0	02/03			0	2	—3	—8
1903	700.3	925.9	887 8	893 6	03/04			3	1	—5	—10
1904	481.0	596 1	580.3	660.1							
1905	782.4	776.0	579.5	777 6							
1906	772 5	723 9	654.1	808.4							
1907	596 7	659.7	607.3	632.3							
1908	630 6	643 8	539.2	629 9							
Av.	596.1	713.2	672.3	797.0							

In the accompanying table I tried to make clear the alternations of dry and wet periods of rainfall for some stations in the Netherlands, by the decadal sums, progressing from year to year, according to the method made use of by BRÜCKNER. In the first place we take Maestricht having the most continental situation of all the meteorological stations in the Netherlands with many years' determinations of rainfall, and being nearest to the basin area of the lower Rhine in Germany (Cleves, Bonn, Triers, Nancy), then Utrecht as intermediate between that station and Helder and Leiduin, which most of all the old stations may approach to the conditions obtaining in the dunes The fifty-years' average rainfall of the three first-named Dutch stations is computed over 1859 till 1908, the average of Leiduin over 49 years only, beginning with 1860, the averages for Germany are over the years 1851 till 1900. The double years indicate the middle of each decade.

Now, what we observe is a close agreement and conformity to the rule of BRÜCKNER, generally, till 1882. In the last (dry) period, however, Helder and, in a still higher degree, Utrecht show important deviations. Maestricht, on the contrary, agrees very well and Leiduin tolerably with Germany and at the same time with by far the majority of all the countries of the world. Also after 1896, till 1900, also in the basin of the lower Rhine in Germany, just as at Maestricht, the rainfall remains considerably below the fifty-years average. About the beginning of the twentieth century the expected change took place every where. In the lower basin of the Rhine in Germany the rainfall in the years 1896 till 1900 exceeds the fifty-years' average by 4, 8, 10, 6 and 4 %, and in the latest lustrum the rainfall at Maestricht was nearly 10 % above the average, but not so at the three remaining stations, where deficits of 5, 11 and 12 % were observed, the wet period evidently not yet having commenced. On account however of the agreement with regular regions, during so long a time, as well as of the circumstance, that anticipation or retardation of an epoch is accustomed to be regained in the next period, the probability must not be called small, that for the whole of the Netherlands an epoch of increased rainfall and of higher ground-water levels is at hand, and that especially in the dunes too the ground-water will soon be rising.

Undoubtedly not only the annual rainfall, but also the evaporation is of consequence for that rising. But we know that evaporation is relatively small in periods of much rain and that, generally, the ground-water rises and falls with the amount of rainfall.

Variations in the rainfall are very strongly indicated by the height

of the ground-water in the dunes. This not only is a consequence of this, that water enclosed in sand must rise three times as much as in an open basin, the supply being equal; but also of that circumstance, that the sand in question is particularly loose and composed of grains with equal dimensions, thus readily absorbing and giving way to the downfalling water. Further favourable conditions are that the ground is very uneven, not admitting of superficial flowing off, and only thinly covered with mosses, grasses, shrubs of *Hippophaë rhamnoïdes*, *Salix repens* and *Ligustrum vulgare* and with loose-crowned trees, especially birches. Really Mr. DE BRUYN found that, even during the dry years 1895 till 1902, at least half the rainfall served as a supply to the ground-water [1]). Moreover the geological constitution of the dune region, where eolian sand reposes upon the very little permeable fine clayey marine sands (Old Sea-clay and Sea-sand of STARING), favours very much the accumulation of the excess of rainfall.

The circumstance that so many low plains amidst the dunes, having subsisted during centuries, have undergone simultaneously quite the same up and down variations in the height of the ground-water, proves, as it seems to me, that we should not, generally, impute the becoming dry of the dunes to a successively filling up of those low places with eolian sand.

Another proof of no less strength I find in the phenomenon, already observed and rightly explained by GEVERS, that, on the whole, the surface line of the plains in the dunes runs parallel to the line of the ground-water, descending toward the sea and toward the polderland.

It is indeed unconceivable that those remarkably flat and pretty well horizontal, often very extensive low grounds amidst the dunes, commonly called in North-Holland "vlakken" and "velden", have had another origin than the sand being blown off — before the time that such blowing off was prevented by the planting of sand-binding grasses — till the level was reached where it was moistened by the ground-water, raised by capillarity to about thirty centimeters above its free level. Really we observe, as far as natural influences preponderate, that generally only where the character of the underground changes, making the water sink down accumulate in such places, in other places, these modifications in the geological structure modify the line of the ground-water, but at the same time, in consequence thereof, that of the surface of the dune plains.

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[1]) Handelingen van het 9de Natuur- en Geneeskundig Congres, 's-Gravenhage, 1903, p. 148.