Essay A Mark 23/36

This essay looks at the potential effects of global warming on the Netherlands.

The topic is too broad to investigate within the word limit and very difficult to cover in general. The geographical setting is well explained but there are too many hypotheses (6), some of which do not relate to the research question. The student does not seem aware that the greenhouse effect is a natural phenomenon and confuses it with the enhanced greenhouse effect, which may have anthropomorphic causes. The data used is from the Dutch meteorological office and is detailed and relevant. Maps are well drawn and the graphs are good but very simple. The student attempts to correlate flooding with warming without fully explaining if and why they might be related. A look at flooding might be relevant if an increase in flood frequency could be proven but the study period is not long enough for this. The student uses simple analysis only to establish a warming trend and fails to do so. The calculation of running means would have helped to do this more effectively. Attempts to correlate annual temperature means and rainfall totals are not relevant to the research question. The essay does not establish that global warming is occurring and does not look at the potential effects on the Netherlands.

Essay A

IBO

International Baccalaureate Organization

Category and candidate number									
Candidate name	Essay A								
School name									
Examination session	Month [May or November]: May						Year: 2003		

EXTENDED ESSAY COVER

Candidates must complete this page and then give this cover and their final version of the extended essay to their supervisor.

IB subject in which this extended essay is registered: Geography

(For an extended essay in the area of languages, state the language and whether it is group 1 or group 2)

Title of the extended essay: The potential effects of global warming in The Netherlands

CANDIDATE'S DECLARATION

If this declaration is not signed by the candidate the extended essay will not be assessed.

The extended essay I am submitting is my own work (apart from guidance allowed by the International Baccalaureate Organization)

I have acknowledged each use of the words, graphics or ideas of another person, whether written, or oral

I am aware that the word limit for all extended essays is 4000 words and that examiners are not required to read beyond this limit.

Signature of candidate:

Date: 16/01/2003

SUPERVISOR'S REPORT

The supervisor should complete the report below and then give this cover, enclosing the final version of the extended essay, to the diploma coordinator. If this report is not signed by the supervisor the extended essay will not be assessed and may be returned to the school

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Comments

If appropriate, please comment on the candidate's performance the context in which the candidate undertook the research for the extended essay, any difficulties encountered and how these were overcome These comments can help the examiner award a level for criterion H. Do not comment on any personal adverse circumstances which may have affected the candidate.

initially became interested in the potential effects of global warming, and the expected rise in sea level in relation to the Netherlands during our studies of atmospheric hazards. A subsequent visit to the deltaworks and storm surge barrier led to the original idea for his investigation. The investigation began with research into the current action being taken to protect the country, both from the sea and the distributaries of the Rhine and Maas rivers. Eventually the climatic statistics were investigated and correlated with the regularity of flooding information to test the relationship, and to consider whether there is any actual evidence of global warming influencing the climate statistics over a period of almost 57 years. (post war.) The study raises some interesting points, and although limited by the relativ short period of time, has made an admirable attempt to answe the original question, and the effects on the preventitive/protection metho which may be needed

I have read the final version of the extended essay, which will be submitted to the examiner.

To the best of my knowledge, the extended essay is the authentic work of the candidate

I spent 3 hours with the candidate discussing the progress of the extended essay.

Signature of supervisor

Date: 20/2/2003.

ASSESSMENT FORM (for examiner use only)

Category and candidate number								

General assessment criteria

Refer to the general guidelines.

	ACHIEVEMENT LEVEL X	maximum	Y
A Research question	2	2	2
B Approach	2	3	2
C Analysis/interpretation	3	4	3
D Argument/evaluation	2	4	2
E Conclusion	2	2	2
F Abstract	0	2	0
G Formal presentation	2	3	2
H Holistic judgement	2	4	2
TOTAL OUT OF 24	15		15

Subject assessment criteria

Refer to the subject guidelines.

Not all of the following criteria will apply to all subjects, use only the criteria which apply to the subject of the extended essay

Criterion J	2	2
Criterion K	2	2
Criterion L	2	2
Criterion M	2	2
Criterion N		
Criterion P	8	8
TOTAL OUT OF 12		

Name of examiner [*CAPITAL letters*]: _____ Examiner number: _____

Signature of examiner: _____ Date: 2 APRIL

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Stage A checker:
Stage B checker:

Extended Essay

"Potential Effects of Global Warming in The Netherlands"

Word Count: 3984

Contents

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Abstract: Extended Essay

"Potential Effects of Global Warming in The Netherlands"

The extended essay research question was to investigate the effects of global warming in The Netherlands. Global warming can be tested by looking at annual temperatures and by looking at annual rainfall amounts. An increase in temperatures would signify a general rise in surface temperature of the earth. With higher temperatures, it would be expected to find increasing precipitation as evaporation rates would increase. This is of relevance to The Netherlands, as higher rainfall amounts would lead to higher flood risks, and The Netherlands is already very vulnerable to floods. The Dutch live with the fear of flooding everyday as two thirds of the country lie below sea level, thus it is always in the back of our heads. This lead to increased interest in this subject. Especially these last few years there have been numerous times that The Netherlands has been face to face with floods. Over the years, the Dutch too became more involved with water management, and have gained a reputation of being amongst the top in the world in water management. Global warming is a combination of both annual temperature and the annual rainfall amounts, thus a correlation was being investigated. In conclusion, it was hard to investigate global warming, as the total time period in which the research was done was too short. To get a more accurate result the time period in which the research is to be conducted, should be longer.

Introduction

"Potential effects of global warming in The Netherlands"

The Netherlands is a small country located in North West Europe. It has a total population of over just 16 million people. Its capital is Amsterdam and because it is located near the coast, it has many ports, the main one being Rotterdam. The majority of the population lives in the Randstad, an area in the West side of the Netherlands, where the largest cities are also located, like Amsterdam, Rotterdam and Den Haag. Over the years, The Netherlands has become to some extent over populated, and has a high population density of 469 persons per square kilometre.

The relief of The Netherlands is reasonably flat. The highest area, or actually hill, is 321 metres high and is located in the South Eastern most point of the country. Two thirds of the country lie below sea level, some places as much as 14 metres. The average of the Randstad area is around five to seven meters below sea level. There are many great rivers flowing through The Netherlands, most enter in the South East of the country, with their mouths at the North Sea in the West of the country. These rivers have large drainage basins, which extend back to Switzerland, Germany and Austria. The main rivers are the Maas and Rijn. They carry large volumes of melt water from The Alps at springtime. There are a few man made lakes in The Netherlands as well, also "polders", which are areas of reclaimed land on which settlements are built for the growing population. A well-known lake is the IJsselmeer, between the provinces in the Northern section of The Netherlands.

Global warming is a well-known phenomenon, but what is it really? There is still great uncertainty as to the effects of global warming and what really causes it, but recent research has shown that it is mainly caused by the Green House Effect. This suggests that the earth is undergoing a steady warming. Since the last ice age, the earth has become five degrees hotter. But it isn't only the temperature that is affected. Precipitation as well, like rain, snow, hail, mist, and thus evaporation rates. If the world is effected greatly by this, areas that are now experiencing dry climates will become wetter and cold areas will become hotter. It might be possible to grow oranges in the South of the UK. With changes in precipitation, some areas will become more vulnerable to storms and they will be appearing more often. Air and ocean currents will become warmer or colder, thus climate will slowly change. The Green House Effect is a result of the emission of greenhouse gasses into the atmosphere. These are gases such as Carbon Dioxide, CFC's, and Methane, which are produced by industries, cows, cars and the burning of fossil fuels. Of course the Green House Effect has been around for a long time, scientists are now talking about the enhanced Green House Effect. This means that humans are contributing greatly to the warming of the earth. The gasses form a layer below the ozone layer, which traps the heat energy from the sun, which is in turn reflected back to the earth's surface. This causes increasing temperatures at the surface.

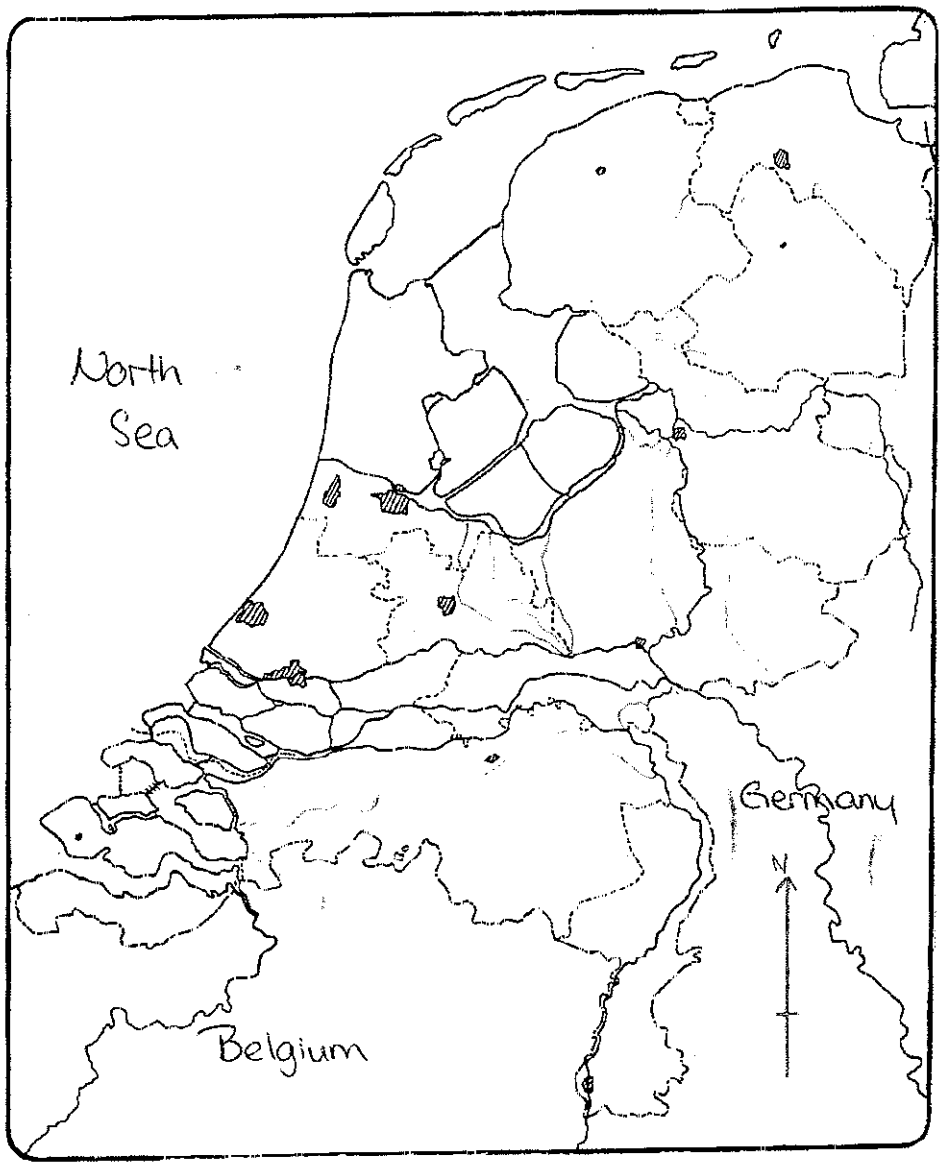
Increased temperatures allow greater amounts of water to evaporate, thus precipitation amounts could increase. What also happens is that ice caps at the North Pole and Antarctica will become weaker and break off. These will melt and disturb ocean currents. Recent research has shown that the earth is at a stage where this is present

There are many other effects but rising water levels are of the greatest threats to The Netherlands, thus this project is based on that.

The Netherlands has had a love-hate relationship with the sea and the water held in the many rivers running through its landscape. Flooding has been something the population has learned to live with. The problem is though, that the water table is relatively high, thus the ground is quickly saturated which increases surface run-off, increasing flood risks. During the winter season, the ground can be frozen, due to which water can't soak into the ground, increasing surface run-off. The rivers carry large amounts of melt water from the Alps and other mountains, and of course the amounts of water that fall within the river's drainage basin. But it isn't only the water in the rivers which cause threats to the population, the sea also plays its role. Storm surges are dangerous and as the prevailing wind is usually directed at the coast, large amounts of water with incredible strength can pile up against the barriers set up. Floods are life threatening and thus large amounts of capital is invested into flood control schemes and water management. Over time, The Netherlands has gained a world reputation in being one of the leading countries with the development of water management schemes. The schemes present are of high quality and of the latest technology. There are different types of flood control schemes in The Netherlands. There are dykes along rivers to reinforce embankments, dunes at the border between land and sea. And the ones that cost the most, the storm surge barriers, the Delta Works and the New Waterway. These are manually controlled and close when a storm is forecasted. Not to forget the dams, which are placed across a river to control the amount of water passing at that point.

The map on the next page shows The Netherlands if it wasn't protected from the sea and rivers by the flood control schemes present nowadays.

Map of The Netherlands.



This map of The Netherlands shows the area of land that would be underwater if there were no flood control schemes at all. There would be no dams, dykes, dunes, or storm surge barriers present anywhere along the coast or alongside riverbanks. About two thirds of the country would be underwater. The green area shows this region and the yellow the area, which won't be flooded. Germany and Belgium don't seem to have these problems to the same extent as The Netherlands does.

Aims

1. To investigate the possible effects of global warming in The Netherlands.
2. To investigate the changes in temperature over a 58-year period.
3. To determine the amounts of rainfall in The Netherlands from 1945 to 2002.
4. To investigate the weather conditions present prior to a flood, concerning temperature and rainfall.
5. To investigate a correlation between the temperature and rainfall data.

Hypotheses

1. It is expected that the average annual temperatures have increased showing evidence of global warming.

2. To find that there is a rise in annual temperatures in The Netherlands.

3. Show that rainfall has increased over the period of 58 years in The Netherlands, showing evidence of global warming.

4. Prior to a flood rainfall should be higher, due to which the ground is saturated.

5. Frozen grounds increase surface run-off increasing flood risks, due to lower temperatures at times of floods.

6. To find a correlation between temperatures and rainfall in The Netherlands.

Methodology

The research done for this coursework was mainly based on the collection of data from the KNMI, the Royal Dutch Meteorology Institute. The daily conditions were collected from which monthly averages were calculated. They were collected from one station in The Netherlands, De Bilt. Which is in the centre of the country. From this, the annual figures were calculated. For both the temperatures and the rainfall, the same procedure was followed with the collection and calculations of the results. The annual figures were then put onto graphs. A mean for the 58-year period was also calculated. With this figure the fluctuation above or below could be found. These figures should show trends in temperatures and amounts of rainfall. Temperature readings were taken in degrees Celsius and rainfall in millimetres. General research was conducted to gain information on global warming and its effects.

Presentation of Results

Floods in The Netherlands

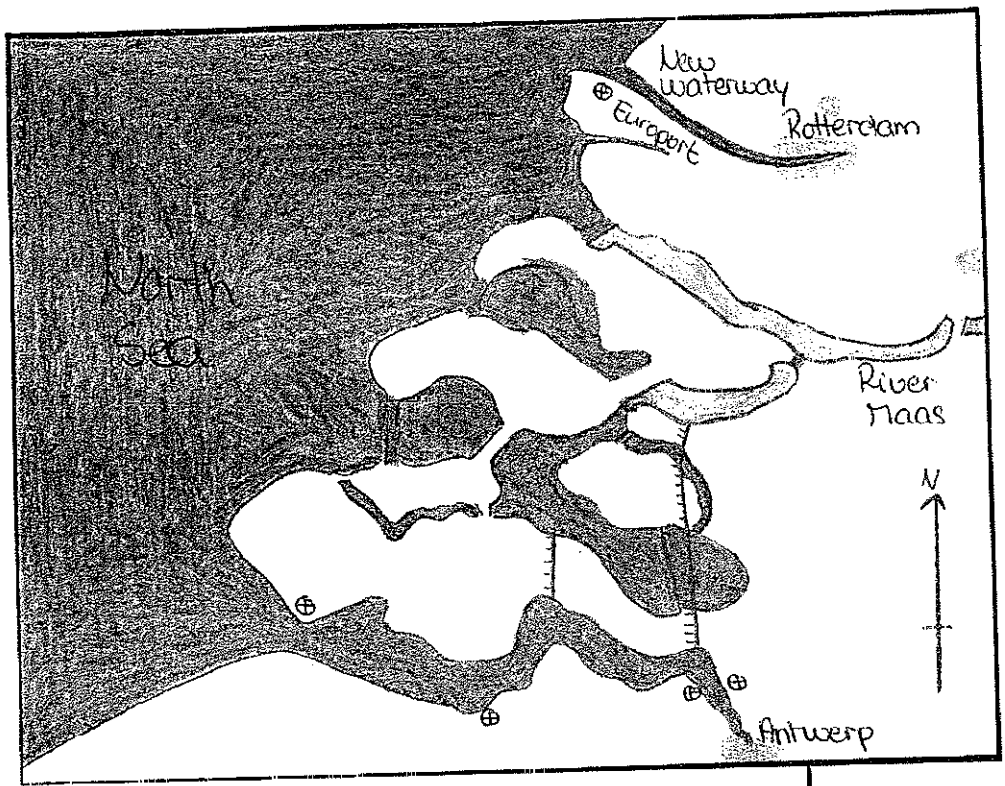
This table shows the floods that have hit The Netherlands from 1945 to 2002. It shows the location and the effects of the flood. With reference to these dates, the climate before hand can be taken from the graphs to see if there is a pattern in the type of weather conditions prior to a flood.

Date:	Location:	Type of Flood:
31/01/53	Zeeland, islands	High tide and a South Western storm surge.
14/01/60	Amsterdam North	River Amstel floods embankments
Dec 1965	East of The Netherlands	River IJssel floods embankments.
Jan 1966	East of The Netherlands	River IJssel floods embankments.
11/03/81	Drenthe Province	High waters in rivers.
Jan 1988	East of The Netherlands	River IJssel floods embankments.
Jan 1993	South of The Netherlands	River Maas and Rijn flood their embankments.
1994	South of The Netherlands	River Maas and Rijn flood their embankments.
Jan 1995	Limburg	River Maas floods its embankments.
13/09/98	South of The Netherlands	River Maas and Rijn flood their embankments.
19/02/02	Limburg	River Maas floods.

These are some major floods that The Netherlands has experienced these last 58 years. It is observed that the rivers, Maas and Rijn flood often. This is because they have large drainage basins. During winter months, large amounts of snow falls there as precipitation and in springtime this melts. All the water has to be taken to the sea, and two of those rivers, which carry these volumes of water, are the Maas and the Rijn. There is a map to show the drainage basin of the Rijn on page 11. In January 1995, most of the rain that caused the flood fell a month before within the drainage basin of the Maas. In total 350 mm of precipitation fell, which is twice as much as usually falls during that period. In some areas more than 70 mm fell within 24 hours, which is thrice the average rainfall. Rainfall is the measure of all types of precipitation, this can be snow, hail, and rain.

The flood in 1953 was of a different nature than all the others mentioned above. It was not caused by a river flooding its embankments. The days before, a storm surge was forecasted, but unfortunately it collided with an extreme high tide level, thus sea levels were higher than usual. The dykes present could not hold back the water, and when the

Map of South West of The Netherlands



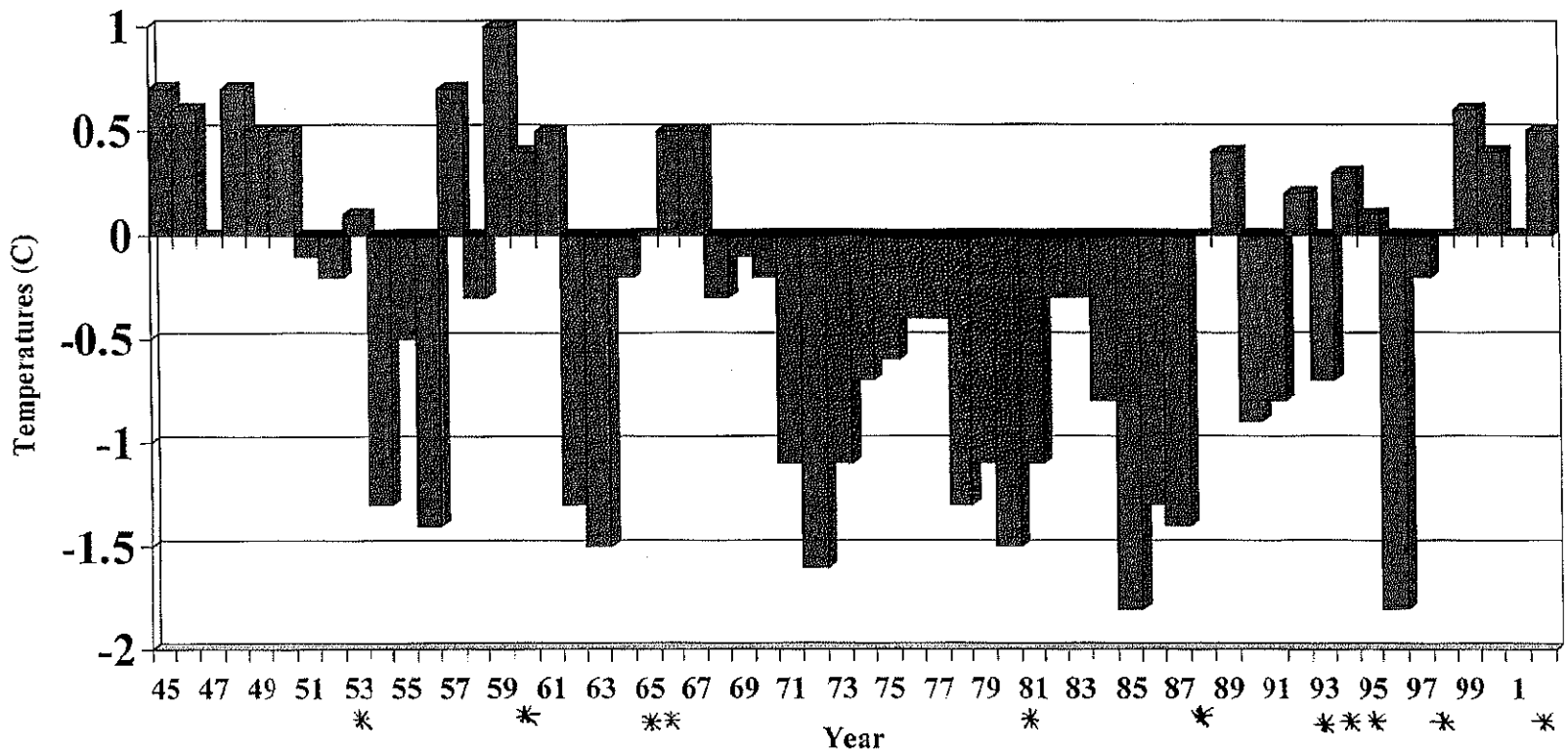
Key

- Salt water
- Fresh water lake
- Reclaimed land
- Sand dunes
- ⊕ Industrial area
- Dams
- Locks
- Channels
- Build-up area

Scale 0 km 20

This map shows the South Western part of The Netherlands, it is mainly focussed on the province of Zeeland. It shows the location of sand dunes along the coast, dams that block waterways, and areas of water that have become fresh. Channels through which transport routes are led, and areas which have since been reclaimed. Some of the build-up areas are also observed, Rotterdam especially, it is the world's biggest harbour. The main flood control scheme that is present in this area is called the Delta Plan, it consists of dams and a storm surge barrier controlling water flow in the inlets.

Graph to show the fluctuation of the annual temperatures compared to the time period average of 10.29 C.



* - Year of flood

Results analysis for annual temperatures.

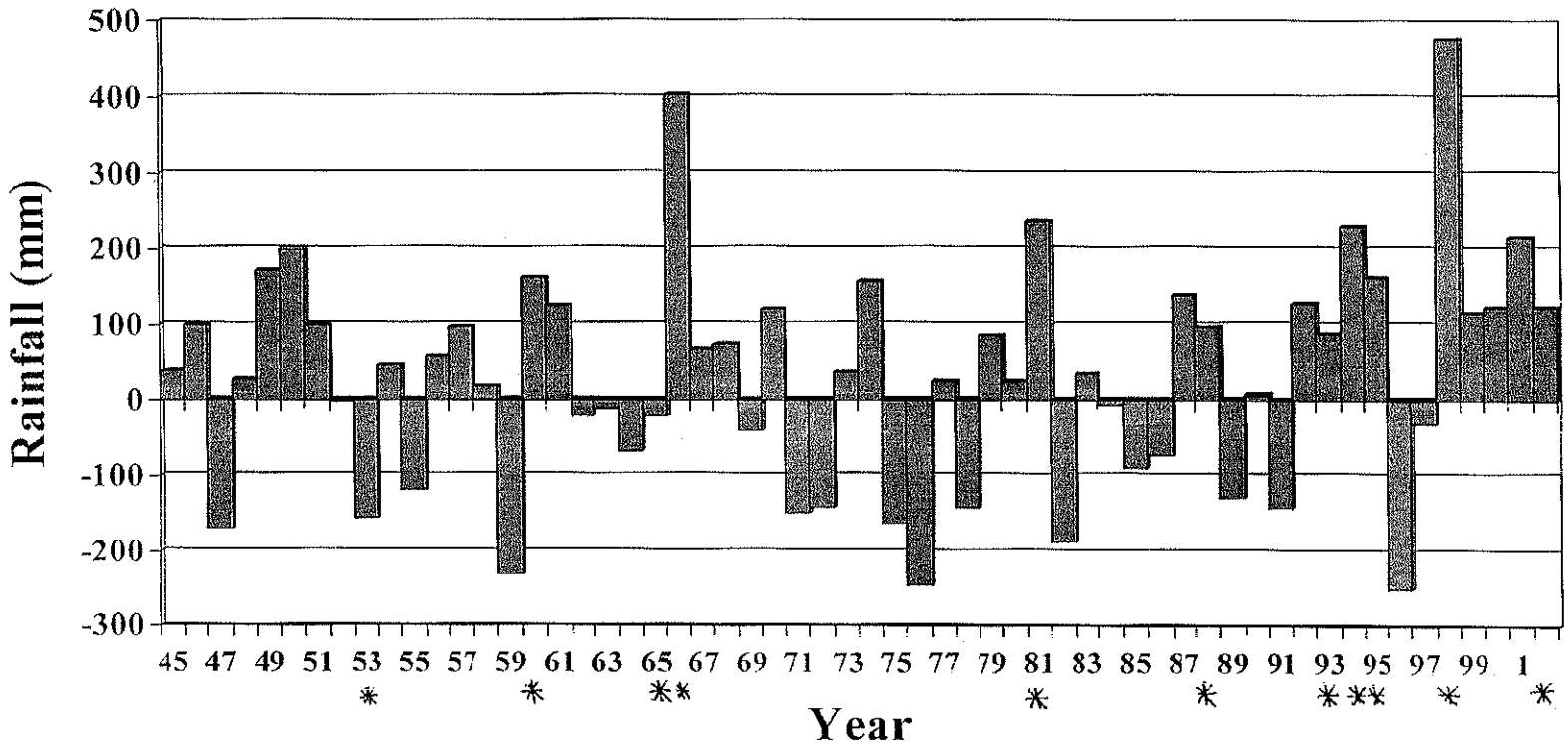
The data was plotted on two graphs, one showing the actual figures of each year and one showing the mean temperature over the 58-year period at the centre and then the fluctuation of the other years with respect to the mean. The mean of the 58-year was 10.29 degrees Celsius. For this analysis the graph showing the fluctuations in temperatures will be used, which is on the previous page.

As can be observed, there is great fluctuation above and below the mean temperature throughout this time period. The years have been marked at which a flood occurred. With this it can be investigated whether there is a pattern present prior to a flood concerning temperatures. There were three years which showed to have extreme values, these were 1985, 1996 and 2002. Only 2002 showed to be a flood year, the other two didn't have any special climatic hazards.

From 1945 until 1950, there was a general increase in temperatures, averaging out above the mean of 10.3 degrees. This was followed by two colder years, which lead till 1953, the year of the flooding in the South West of The Netherlands. That was a slightly warmer year, an increase of 0.1 degree. The next three years from 1954 until 1956 were relatively colder. They were nearly 1 degree below the mean. The following five years showed fluctuation, but overall gave an increase in temperatures. A cold period of three years took until 1964, which was followed by three years of warmer temperatures. The next twenty years gave strange results. This was a period where temperatures were constantly below the mean. And some years showed to have quite a large change of over 1.5 degrees below the mean. Only in 1981, though, there was a flood, and the period ended in 1988, in which there was a flood as well. Temperatures fluctuated from a maximum of –1.8 degrees to –0.1 degree Celsius. This period gave a steady cooling of The Netherlands, but did not have major effects on the country. From 1988 until 1995 there was great fluctuation above and below yet again. In this period of time there were also numerous floods, relatively many over a short period of time. In the years 1988, 1993, 1994 and 1995 flooding occurred. 1996 was an anomaly, with 1.8 degree below the average. After this, there was a steady increase in temperatures.

Looking back at the years in which floods occurred they don't show a pattern of similar temperatures. In general, the years which experienced floods did seem to have higher temperatures than the mean, but there is no clear pattern to be found.

Graph to show the fluctuation of the annual rainfall around the mean of 788.2 mm, over the period of 58 years.



* - Year of flood

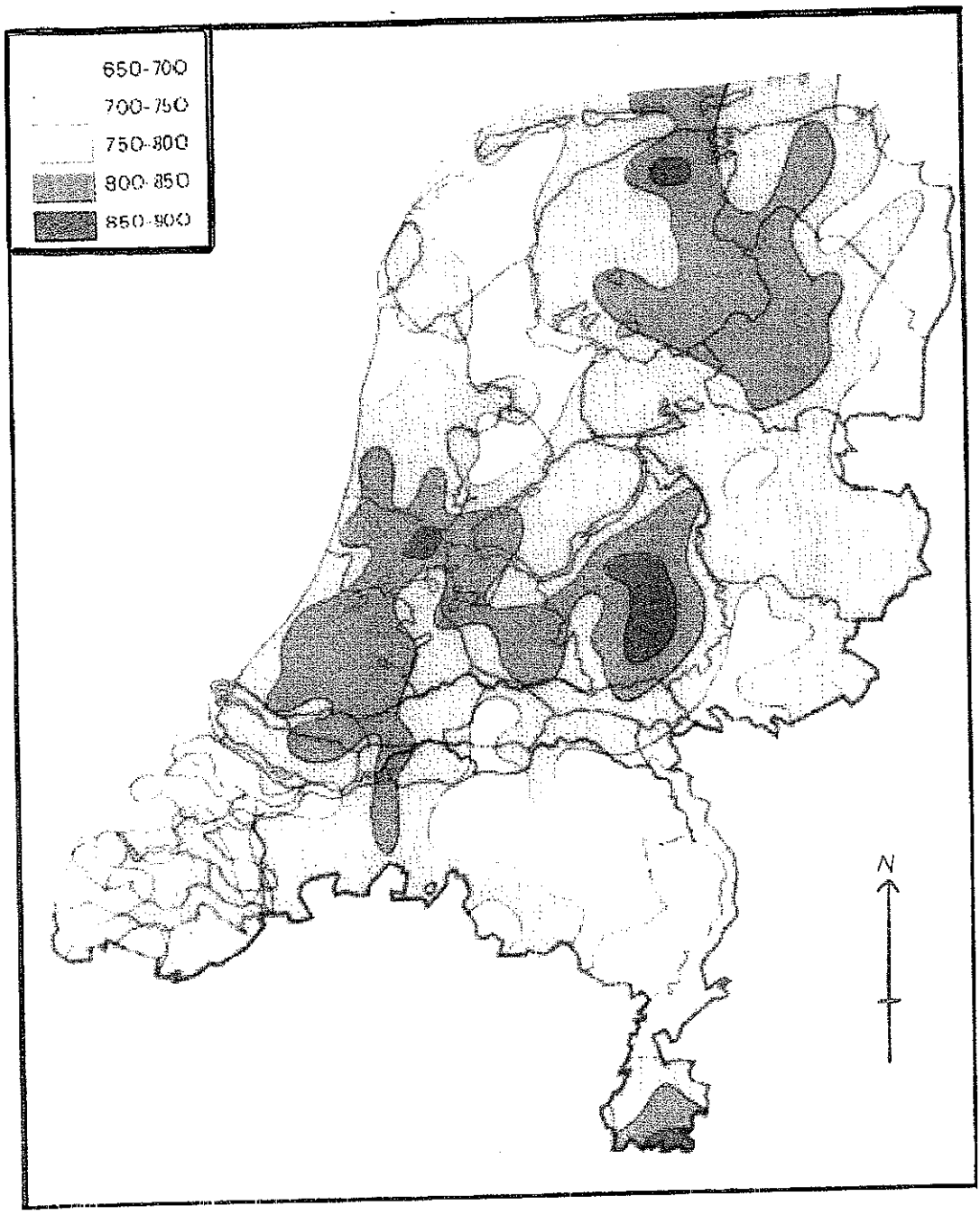
Results analysis for the annual rainfall data.

The results were plotted on two graphs, one, which showed the actual yearly figures, and one, which showed the fluctuation compared to the mean of the 58-year period. The mean of this period of time is 788.2 mm. For this analysis the graph showing the fluctuations will be used. The years in which major floods occurred were marked on the graph for further analysis.

What is clearly seen is that the annual rainfall figures fluctuate greatly, there is no pattern to be found. In general though it can be said that there is a gradual increase, as the bars above the mean occupy a larger volume than the bars below the mean. There are a few anomalies, which stand out amongst the other results. These occurred in the years 1959, 1966, 1976, 1981, 1994, 1996, and 1998. The years 1959, 1976 and 1996 were years that were below the mean rainfall. These were not flood years. The remaining years, 1966, 1981, 1994 and 1998 were years, which showed to have total rainfall amounts above the mean. These were all years that had fluctuations greater than 200 mm of rainfall above or below the mean. The remaining years on the graph all fluctuate between the boundaries of –200 mm and 200 mm to the mean. They form very small groups or clusters together. Most of the groups don't exist of many years with a steady increase or decrease seen relatively to the mean. The largest group consisted of five years which appeared during 1948 to 1952, other groups consisted of 4 or less steady fluctuating years.

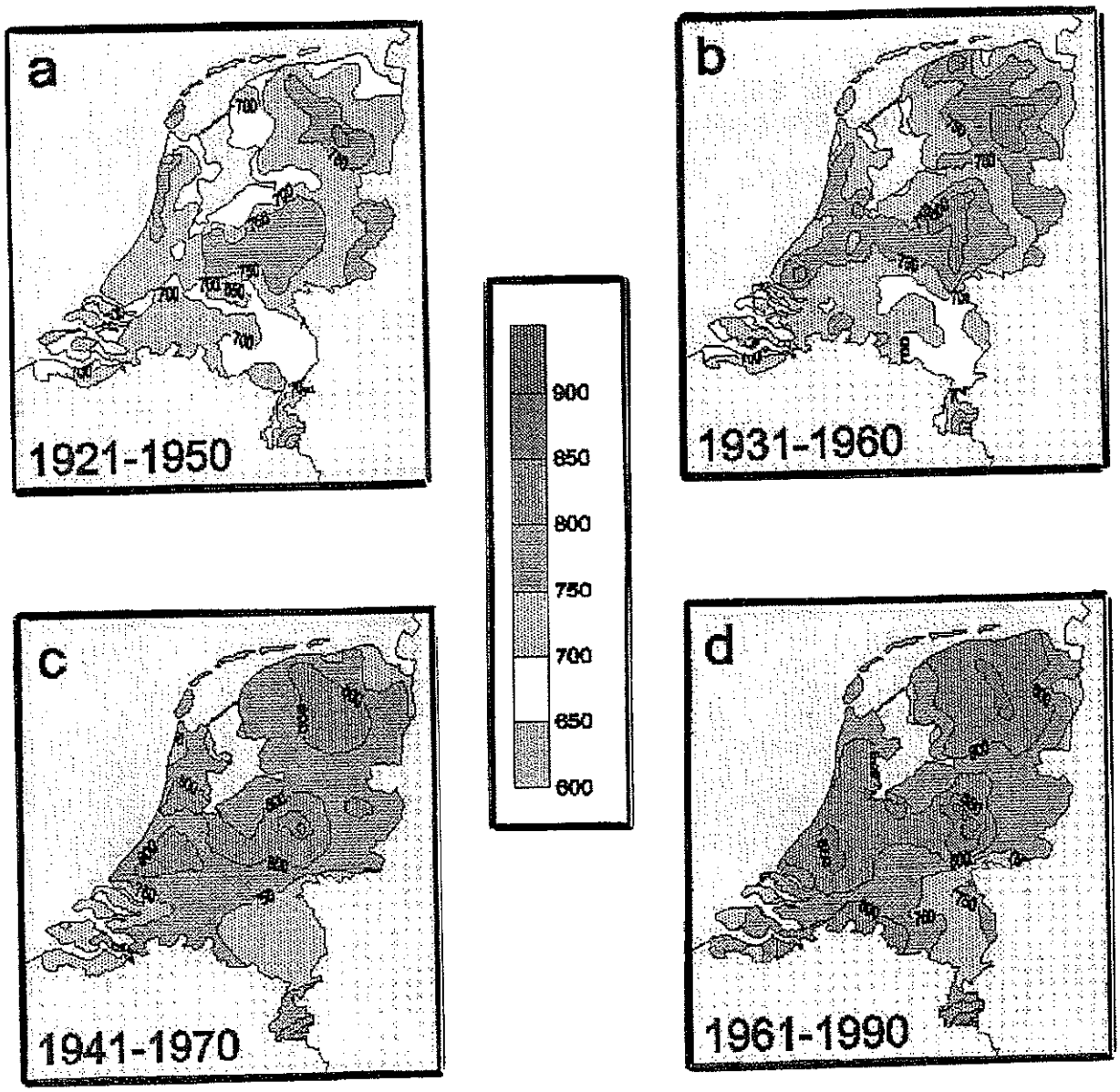
These results are interesting looking at the years in which major floods hit. All the flooding years show to have an increase in annual rainfall figures, except for the flood in 1953, but that wasn't caused by heavy rainfall. All the other floods were caused by heavy rainfall which then had to carried by the rivers to the North Sea. These rivers usually flooded their embankments. The flood in 1965 did show to have a decrease in the amounts of rainfall, but that is due to the fact that it occurred in the end of December of that year and continued in January 1966 which was also a flood year. Although the years which experienced floods didn't all have large increases in annual rainfall, they tend to be around or above the 100-mm mark. Some years being an exception like 1966 and 1998, these two years experienced large amounts of rainfall. As The Netherlands' water table is relatively high, the ground is quickly saturated, thus water can't infiltrate into the soils increasing surface run-off. Usually the precipitation falls within a few months of the year in a short period of time, and this is what then causes the flooding. During wintertime, flood risks are greater as the ground is often frozen, thus water can't infiltrate below the surface increasing surface run-off and reducing evaporation due to cooler temperatures.

Map of The Netherlands Showing Rainfall Distribution.



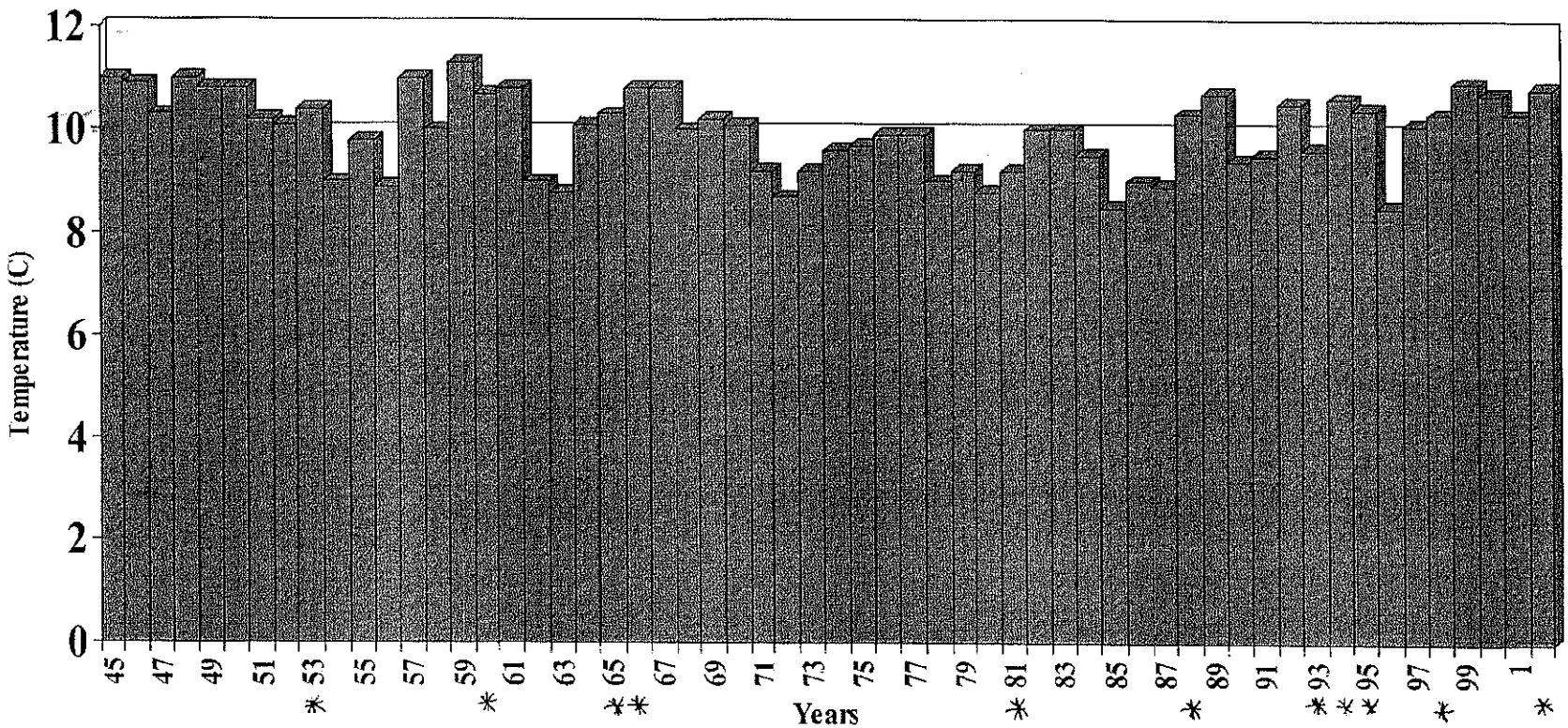
This map shows the rainfall distribution from 1951 to 1980 in The Netherlands. The measurements are taken in millimetres and by the use of the colour code, the distribution is easily seen. It can be observed that most of the rainfall fell in the centre of the country and in the North East corner. Also in the South East, high rainfall was recorded during this time period. Although these results concern a long period of time, it is only to show where most of the precipitation falls and how it is distributed throughout the country. Areas of low precipitation are found mainly in the South West and the South East of the country, the North West also shows to have less amounts of rainfall.

Rainfall Distribution Maps of The Netherlands



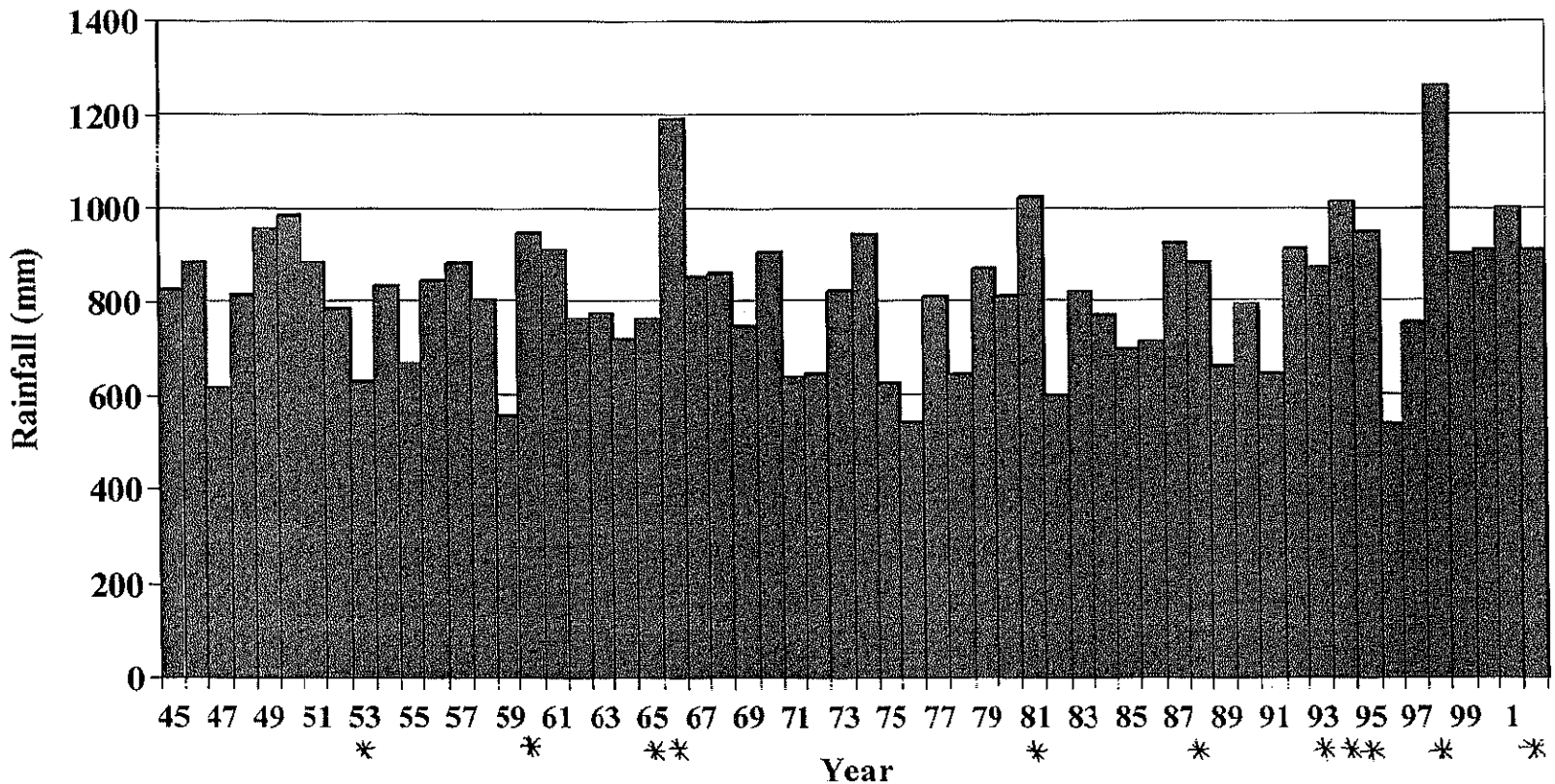
This is a combination of maps of The Netherlands showing the rainfall distribution patterns of different time periods. The time periods flow over into each other and are significant over the total time period of 70 years. There is a map missing between map C and map D, this one is enlarged on the previous page for the time period from 1951 to 1980. The general pattern that can be seen on the maps is that the total amounts of rainfall increase over the 70-year time period. This can be observed by the colour code, measurements are taken in millimetres. The colours become darker and from 1941 onwards, the yellow totally disappears. Overall there is an increase in the amount of rainfall in The Netherlands. The areas which experience more than 900 mm of rainfall, increase in size over the years, thus it can be said that rainfall amounts are increasing.

Graph to show the average annual temperatures over the time period from 1945 to 2002.



* - year of flood

Graph to show the annual rainfall figures for the last 58 years until 12/10/2002. The average of this period of time is 788.6 mm.



*- year of flood

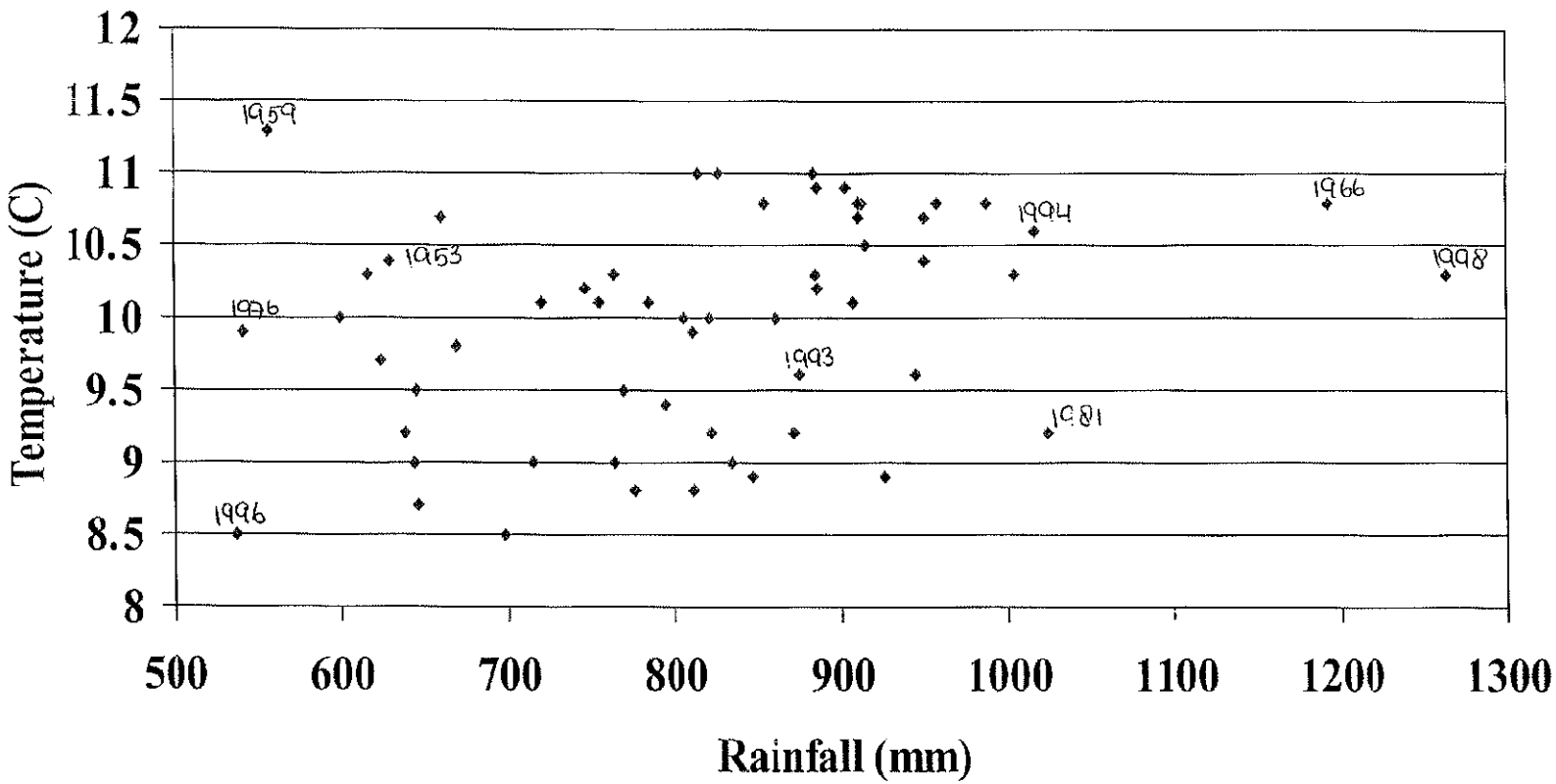
Results analysis to investigate global warming.

Global warming is mainly caused by the Green House Effect and the enhanced Green House Effect. The two graphs showing the total temperatures and the total rainfall for each year are being used to analyse this concept.

First the temperatures for the 58-year period. The detailed pattern was explained in the previous analysis. What can be observed from this graph is a general decrease in annual temperatures from 1945 until 1956. From then on there is a general increase in temperatures till 1961. After which there is a downward sloping curve with slowly decreasing annual temperatures which steady out in 1974. The average temperature stays steady until 1986, from which it slowly increases with an anomaly at 1995. But the general trend from 1986 until 2002 is showing to have increasing temperatures. Although it is hard to interpret this data a general statement can be made. Overall there was a slight increase in temperatures, as the increases were larger than the decreases.

The rainfall statistics are more complicated. Again the graph can be divided up into sections of either increasing, decreasing or stable rainfall amounts. Starting from 1945 there was a slight increase until the year 1951, after this a period of fourteen years followed through which the rainfall was relatively steady. The increases managed to cancel out the decreases. From 1965 until 1969 there was a period of increasing rainfall figures. The next years until 1991 are again a period of steady rainfall amounts. There were fluctuations present but overall relatively constant. From than on until 2002, the trend was of an increasing form with 1995 as an anomaly. The overall trend shows that there is an increase in the amount of rainfall as the periods of increasing rainfall amounts occurred more often than periods with decreasing rainfall figures.

Scatter graph to show correlation between rainfall and temperatures during the 58 year period.



Results analysis for the scatter graph.

With the use of a scatter graph, the correlation between temperature and rainfall was investigated. They were plotted against each other to look for a pattern. Every blue spot marks a year on the graph from the period of 1945 to 2002. The blue spots that have the year written above it are either to show the years in which major floods occurred or years which stand out.

It is strange that there are a few years that totally stand out from the rest of the data. The most obvious is the year 1998, total rainfall was 1263 mm and the annual temperature was 10.3 degrees. Looking back, this is also a year in which a major flood hit The Netherlands, due to heavy rainfall. The temperature was similar as the 58-year period average, thus it was not a particularly cold or hot year, but the rainfall was much higher. 1966 was another year that stood out of the rest. Total rainfall that year was 1192 mm and the annual temperature was 10.8 degrees, both these results were above their means respectively. Again this is also a year that The Netherlands was struck by a flood. Rivers flooding embankments caused both these floods.

Years with extremely low amounts of rainfall were 1959, 1976 and 1996. These did have great fluctuation in annual temperatures, from 11.3 degrees, 9.9 degrees and 8.5 degrees respectively. There were no major floods during these years. But that 1959 was relatively dry is strange, as the annual temperature was high, it would be suspected that evaporation rates would increase which would in turn increase the amount of precipitation. In 1953, a storm surge hit the South West of The Netherlands causing large areas of land to flood, this year is also marked but doesn't show to have any abnormal results

Other major flood years, like 1993, 1981, and 1994 are amongst the body of results. 1994 and 1981 are at the boundary of the body, with annual rainfall figures which exceed the 1000 mm mark. 1981 also showed to have a relatively lower temperature of 9.2 degrees Celsius. There was a flood in 2002 in the month of February, due to a river flooding its banks. There was also a heavy storm surge that hit North West Europe during October, resulting in the closure of the storm surge barrier in the South West of The Netherlands.

Spearman Rank Correlation

Year	Temperature	Rank	Rainfall	Rank	D	D^2
45	11.0	23	827	30	7	49
46	10.9	22	886	37	15	225
47	10.3	16	616	5	11	121
48	11.0	23	815	27	4	16
49	10.8	21	958	46	25	625
50	10.8	21	988	47	26	676
51	10.2	15	886	37	22	484
52	10.1	14	785	23	9	81
53	10.4	17	630	7	10	100
54	9.0	5	834	30	25	625
55	9.8	11	669	14	3	9
56	8.9	4	846	31	27	729
57	11.0	23	884	35	12	144
58	10.0	13	806	25	12	144
59	11.3	24	557	3	21	441
60	10.7	20	950	45	25	625
61	10.8	21	913	41	20	400
62	9.0	5	765	20	15	225
63	8.8	3	776	22	19	361
64	10.1	14	720	17	3	9
65	10.3	16	765	20	4	16
66	10.8	21	1192	51	30	900
67	10.8	21	854	32	11	121
68	10.0	13	861	33	20	400
69	10.2	15	747	18	3	9
70	10.1	14	908	39	25	625
71	9.2	6	639	8	2	4
72	8.7	2	646	11	9	81
73	9.2	6	823	29	23	529
74	9.6	9	945	44	35	1229
75	9.7	10	625	6	4	16
76	9.9	12	542	2	10	100
77	9.9	12	812	26	14	196
78	9.0	5	644	9	4	16
79	9.2	6	872	34	28	782
80	8.8	3	812	26	23	529
81	9.2	6	1024	50	44	1936
82	10.0	13	600	4	9	81
83	10.0	13	822	28	15	225
84	9.5	8	770	21	13	169
85	8.5	1	698	15	14	196
86	9.0	5	715	16	11	121
87	8.9	4	927	43	39	1521

88	10.3	16	885	37	21	441
89	10.7	20	660	12	8	64
90	9.4	7	795	24	17	289
91	9.5	8	645	10	2	4
92	10.5	18	915	42	24	576
93	9.6	9	875	35	26	676
94	10.6	19	1016	49	30	900
95	10.4	17	950	45	28	784
96	8.5	1	538	1	0	0
97	10.1	14	756	19	5	25
98	10.3	16	1263	52	36	1296
99	10.9	22	903	38	16	256
00	10.7	20	911	40	20	400
01	10.3	16	1004	48	32	1024
02	10.8	21	911	40	19	361

This table shows results of both temperatures and rainfall for each year. Each was ranked and the difference was found. Negative values will be eliminated anyway, when the square is taken. To proof the Spearman Rank Correlation Coefficient (SRCC), there is a formula:

$$1-\left[6 \times \sum d^2 \ / \ (n^3-n)\right]$$

This formula means that six (6) times the sum of all d^2 values is divided by the number of terms cubed (n^3) minus the number of terms (n). This value is then subtracted from one (1). With the data above, the SRCC equals

$$1-\left[6 \times 22843 \ / \ (58^3-58)\right]$$

$$=$$

$$1-\left[1357058 \ / \ 195054\right]$$

$$=$$

$$0.297 \text{ (3sf)}$$

For geographers to be satisfied with a correlation, the SRCC should either lie between +0.7 and +1.0, or between –0.7 and –1.0. With the data above this is not true.

Conclusion

The research question of this extended essay was:

"Potential effects of global warming in The Netherlands".

In this conclusion section each hypothesis will be taken individually and either proved true or false.

1. It is expected that the average annual temperatures have increased showing evidence of global warming.

To conclude this hypothesis, look at the graph showing annual temperatures. Global warming is present when there is proof of a general increase in temperatures. From the statistics it can be observed that there is a slight increase over the 58-year period studied. Due to the short time period studied, where there was great fluctuation, it is not adequate to state whether global warming was proved.

2. To find that there is a rise in annual temperatures in The Netherlands.

Looking at the analysis of the graph showing temperature data and the temperature graph, it is concluded that there is an increasing trend in temperatures. There are several fluctuations present over the 58-year period, but the general pattern shows that there is a slight increase. But to be able to proof this hypothesis, the time period is too be extended in length.

3. Show that rainfall has increased over the period of 58 years in The Netherlands, showing evidence of global warming.

Taking the graph and analysis of the rainfall statistics, it can be concluded that there is a general increase in rainfall amounts. This is a result of global warming, thus an increase in rainfall will proof global warming. Again the time period is too short to proof global warming due to increased rainfall amounts in The Netherlands.

4. Prior to a flood rainfall should be higher, due to which the ground is saturated.

This was proven to be true for eight out of the ten floods. The flood in 1953 disproves this hypothesis, but that flood wasn't connected with high rainfall. Rivers overflowing their embankments flooding inland areas caused all the other floods. The 1965 flood proved this to be false. But this flood was from December '65 until January '66. Thus the rainfall might not have met its peak by the end of 1965. But with eight out of ten, this hypothesis is proven to be true.

5. Frozen grounds increase surface run-off, increasing flood risks due to lower temperatures at times of floods.

Frozen grounds occur when temperatures are below zero, which usually occur during winter. In order to proof this hypothesis, the time of the year that most of the floods occur should be around November to February. Eight out of ten floods took place during that period of the year. One of the floods no month was given and the other flood occurred in September 1998 that disproved this theory. The majority of floods occurred during colder months. This might also be because during winter, The Netherlands experiences extreme weather conditions and is hit by storms more often. This hypothesis is proven to be true for the majority of floods in The Netherlands.

6. To find a correlation between temperatures and rainfall in The Netherlands.

To prove this hypothesis, the scatter graph and the Spearman Rank Correlation Coefficient should be taken into account. The Coefficient that was obtained from the Spearman Rank Correlation was 0.297, which proves that there is no correlation between temperature and rainfall. Observing the scatter graph shows that there is no line of best fit that can be drawn. There is no pattern shown that when temperatures are high, rainfall is high, or vice versa. This hypothesis is proven to be false.

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ASSESSMENT FORM (for examiner use only)

Category and candidate number								

General assessment criteria

Refer to the general guidelines

	ACHIEVEMENT LEVEL X	maximum	Y
A Research question		2	
B Approach		3	
C Analysis/interpretation		4	
D Argument/evaluation		4	
E Conclusion		2	
F Abstract		2	
G Formal presentation		3	
H Holistic judgement		4	
TOTAL OUT OF 24			

Subject assessment criteria

Refer to the subject guidelines

Not all of the following criteria will apply to all subjects; use only the criteria which apply to the subject of the extended essay.

Criterion J		
Criterion K		
Criterion L		
Criterion M		
Criterion N		
Criterion P		
TOTAL OUT OF 12		

Name of examiner [*CAPITAL letters*]: _____ Examiner number: _____

Signature of examiner: _____ Date: _____

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Stage A checker:
Stage B checker: