# Daily Loads of Nutrients, Total Alkalinity, Dissolved Inorganic Carbon and Dissolved Organic Carbon of the European Continental Rivers for the Years 1977 – 2009

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*January, 2011*

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*January, 2011*

# Contents

**Abstract**

The daily nutrient loads of the European continental rivers entering the North Sea are estimated for the years 1977 to 2009. The parameter treated are total nitrogen, nitrate, ammonium, total phosphorus, orthophosphate and silicate. Additonally for the rivers Elbe, Ems, Nieuwe Waterweg, Haringvliet and Scheldt the loads of Toatal Alkalinity (TALK), dissolved inorganic carbon (DIC) and dissolved organic carbon (DOC) are presented.

The raw data, in most cases daily values of discharge and nutrient concentrations sampled weekly, biweekly or monthly, are illustrated and statistically discussed. The observations used are: total nitrogen, Kjeldahl nitrogen, nitrate, nitrite+nitrate, ammonium, total phosphorus, orthophosphate and silicate.

Based on the investigations of annual load estimates by De Vries & Klavers (1994) the "double interpolation method" to calculate daily loads is used. Adopting their arguments general problems of load estimates are flagged. These arguments help to understand the advantages and disadvantages of the method used in relation to the individual nutrients. A further description on the method used as well as a discussion on the time series of the resulting river loads is presented in the paper by Radach and Pätsch (2007)

The carbon related loadings of TALK, DIC and DOC result from different measurements by A. Borges (pers. comm) that resulted in one representative concentration for each river and each parameter.

The graphical and statistical tools already used for the discussion of the raw data are also applied to the resulting daily river loads.

Under the restrictions also flagged in this report, the calculated values build a good estimate for the daily nutrient loads for further use in ecosystem models.

This report and all data shown are available on the website of the Institut für Meereskunde Hamburg (IfM) under:
http://www.ifm.zmaw.de/forschung/theoretische-ozeanographie/modelle-und-daten/

# 1 Introduction

Over the years a range of eutrophication problems have been well documented. The source of these problems is generally understood to be excessive nutrient concentrations (Ospar, 1998). Listing the pathways of nutrients into the North Sea a considerable portion is provided by river nutrient loads and diffusive inputs of nutrients along the coast (Nelissen & Stefels, 1988; Radach *et al.*, 1990; Radach, 1992; Radach & Pätsch, 2007).

Even though the dynamical link between nutrient river input into the North Sea and coastal eutrophication problems has been realized, papers like the Quality Status Report 2000 (Ospar, 2000) deal with this topic only on the basis of estimates for annual river loads. In order to investigate the effects of these inputs with an ecosystem model, the information provided clearly lacks the resolution of the seasonal pattern.

The first attempt to provide adequate estimates of river loads was made by the NSTF guiding document (Anonymous, 1992), where monthly values of all major rivers around the North Sea were aggregated for the year 1985. Estimates of daily nutrient loads for the continental rivers were presented by Pätsch & Lenhart (2004) for the years up to 2002.
The present paper is an update of the former report, providing an extension of the time range to cover the years from 1977 to 2009 for continental rivers entering the North Sea, as presented in Fig. 1.

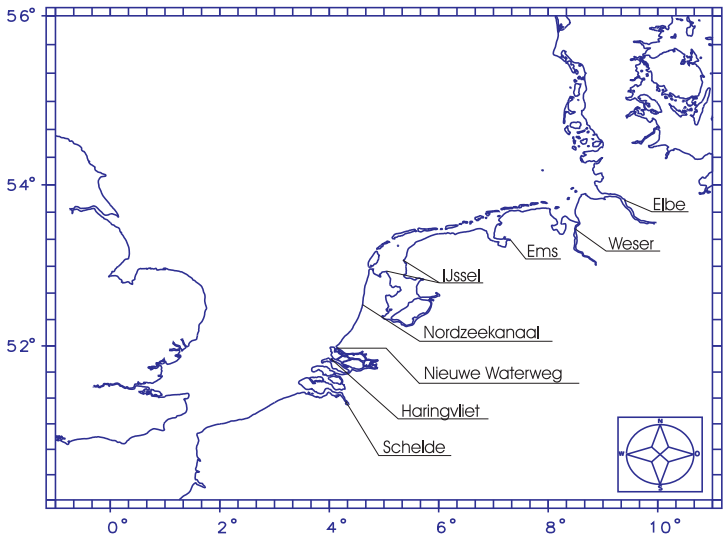



**Fig. 1:** *The main continental rivers entering the North Sea.*

The nutrient loads described here build an important piece of information on the nutrient loads for the North Sea as a whole. They were used in an OSPAR ecological modelling workshop, where the reduction scenarios for the ecosystem model simulation were related to the reduction effort achieved by the indicidual countries around the North Sea since 1985, the year where the 50 river loads of DIN and DIP was suppose to start. The related year, for which he reduction levels acheived were tested, was 2002, the year where OSPAR provided a first assessemt on the eutrophication status of the North Sea, based on the Comprehensive Procedure. The result of the ecosystem modelling workshop and the discussion on the river loads in the context of the reduction scenarios is presented in Lenhart et al. (2010).

The following institutions kindly provided data for the river load calculations:

- Arbeitsgemeinschaft für die Reinhaltung der Elbe (ARGE), Hamburg, FRG
- Bundesanstalt für Gewässerkunde, Koblenz, FRG
- NLWKN, Hildesheim, FRG
- Rijkswaterstaat,Den Haag, NL
- University of Liege, Chemical Oceanography Unit, Institut de Physique (B5), B-4000 Liege, Belgium

## 2 The raw data: an overview

Table 1 gives an overview of the original data provided by the different river authorities. The numbers within the boxes give the years of the beginning and the end of the available time series for the specific parameter.

**Tab. 1a:** *List of parameters aggregated for each river*

| River | DIS | TN | KjN | NO3 | NO2 | N23 | NH4 | TP | PO4 | SiO4 | Cl |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Elbe | 77-09 | 78-09 | | 77-09 | 90-09 | | 77-09 | 78-09 | 77-09 | 88-09 | 77-09 |
| Weser | 77-09 | 80-09 | | 77-09 | 90-05<br>07-09 | | 77-09 | 77-09 | 81-09 | 93-94 | 90-09 |
| Ems | 77-09 | 80-09 | | 77-09 | 90-09 | | 77-09 | 77-09 | 81-09 | 89-94 | 90-09 |
| Lake IJssel | 77-09 | 77-09 | 77-09 | 2004 | | 77-03 05-09 | 77-94<br>98-09 | 77-09 | 77-09 | 77-94<br>99-09 | 77-09 |
| NZ Kanaal | 77-09 | 77-09 | 77-09 | 2004 | | 77-03 05-09 | 77-94<br>98-09 | 77-09 | 77-09 | 79-94<br>99-09 | 90-94<br>98-09 |
| N. Waterweg | 77-09 | 77-09 | 77-09 | 2004 | | 77-03 05-09 | 77-09 | 77-09 | 77-09 | 77-94<br>99-09 | 90-09 |
| Haringvliet | 77-09 | 77-09 | 77-09 | 2004 | | 77-03 05-09 | 77-94<br>98-09 | 77-09 | 77-09 | 77-94<br>99-09 | 90-94<br>98-09 |
| Scheldt | 77-09 | 77-09 | 77-09 | 2004 | | 77-03 05-09 | 77-94<br>98-09 | 77-09 | 77-09 | 77-94<br>99-09 | 90-94<br>98-09 |

The abbreviations and the units for the parameters are:

| | | |
|---|---|---|
| DIS | discharge; | $[m^3/s]$ |
| TN | Total nitrogen | $[mg/l]$ |
| KjN | Kjeldahl nitrogen | $[mg/l]$ |
| NO2 | Nitrite | $[mg/l]$ |
| NO3 | Nitrate | $[mg/l]$ |
| N23 | Nitrite + Nitrate ($NO_2$ plus $NO_3$) | $[mg/l]$ |
| NH4 | Ammonium | $[mg/l]$ |
| TP | Total phosphorus | $[mg/l]$ |
| PO4 | Orthophosphate | $[mg/l]$ |
| SiO4 | Silicate | $[mg/l]$ |
| Cl | Chloride | $[mg/l]$ |

For some of the raw data, like chloride and NO2, generally no time series of daily loads are calculated. These data are only included as additional information to complete the overall picture of the data. One should point out that the timeseries described in Tab. 1 may have gaps which can only be recognized by looking at the presentation of the individual parameter. The data presented here are only a subset of the data available at the authorities, here collected for specific aim of load calculations.

For the Dutch and Belgium rivers total nitrogen is calculated as the sum of Kjeldahl nitrogen, nitrite and nitrate. Kjeldahl nitrogen includes particulate organic nitrogen (PON), dissolved organic nitrogen (DON), and ammonium.

$$KjN = PON + DON + NH_4$$

For the German rivers the values for total nitrogen are not differentiated into Kjeldahl- and nitrite/nitrate-nitrogen. Here the originators delivered values for total nitrogen, nitrate and ammonium.

The abbreviations and the units (assuming density 1 kg/l) for the carbon related parameters are:

| | | |
|---|---|---|
| TALK | Total Alkalinity; | $[\mu mol/kg]$ |
| DIC | Dissolved Inorganic Carbon | $[\mu mol/kg]$ |
| DOC | Dissolved Organic Carbon | $[\mu mol/kg]$ |

Only for some of the rivers a constant concentration value for these parameters could be estimated:

**Tab. 1b:** *List of estimated concentrations ([µmol/kg]) for some rivers*

| River | TALK | DIC | DOC |
|---|---|---|---|
| Elbe | 2231 | 2195 | 456 |
| Ems | 2562 | 2738 | 1007 |
| N. Waterweg | 2580 | 2678 | 230 |
| Haringvliet | 2580 | 2678 | 230 |
| Scheldt | 3832 | 3971 | 512 |

Some problems regarding the interpretation of the data should be mentioned. Since the North Sea is a tidally influenced shelf sea the inflowing rivers show typical estuarine characteristics. McLellan (1977) classified these regions as: "The term estuary has been traditionally used by geographers to denote rather loosely the lower reaches of a river where tide and river flow interact". Therefore any measurement monitoring the outflowing river waters has to take into account the phenomena of mixing water masses. In order to get a pure sample of the river water, it should be taken at low tide so that mixing processes can be considered to have a minor influence. A valuable information about the state of mixing within the water mass is given by the chloride content of the sample.

The discharge is usually measured at the last tide-free gauge station. In order to account for the additional contribution of the downstream part of the river, certain factors are provided by the different authorities monitoring the rivers. These factors will be mentioned in the description of the raw data but they did not enter the load estimates within this paper. The idea of providing the load estimates based on the raw data was that someone who wants to use the data can decide himself in the frame of his own application if he wants to apply a drainage factor or other additional factors, like a retention factor.

In contrast to the position of the discharge measurements the position of the concentration measurements are oriented towards the river mouth. In this way the concentration measurement represents as good as possible the state of the river entering the North Sea. Of course this site must allow to identify the outflowing water. Practically the selection of the monitoring station for the load calculation is determined by the frequency of the measurements available and the state of tidal mixing at that station, which may be checked by the chloride contents of the samples. Therefore there is a spatial difference between the position where the discharge is measured and the sampling stations for the nutrient concentrations. This is definitely a drawback for the load estimates, but one has to consider the load calculations from discharge and concentration data as the best estimates possible, given the restrictions by the data as well as the assumptions that have to be applied.

# 3 Description of raw data : discharge and concentrations

The raw data, i.e. discharge and concentrations for each river, are presented by time series plots. These figures also include a low-pass filtered curve based on the actual monthly mean values. The low-pass curve can be interpreted as interannual fluctuation or trend. It is calculated by a running average of 13 consecutive monthly means. In order to deal with complete years of monthly means the size of the first and the last weight is reduced to the half of each other weight. This leads to 13 weights:

(1/24, 1/12, 1/12, ... , 1/12, 1/12, 1/24)

The choice of the window width is a compromise between a highly fluctuating and a very smooth curve with the intention to filter out the seasonal cycle within a year.

Furthermore the climatological annual cycle derived from the actual monthly means and their corresponding standard deviations from all years available are presented as an additional plot. These were derived by first calculating a monthly mean for every month within all the available years. In a second step a climatological mean was derived for each month by calculating, e.g. a climatological mean January value from all mean January values. The climatological monthly means are presented as bar charts with the resulting standard deviations given as bars, representing the interannual fluctuation for the single months over all available years. In case the data do not cover more than one monthly mean value, this is plotted equal to a climatological monthly mean value, but of course there is no standard deviation added.

The characteristics of the data, as presented in the different figures are also described as text in a unified way. Concerning the time versus value plot (TIME SERIES) the number of data, maximum and minimum values, the mean of all the data $\mu$ as well as the relative standard deviation ($\frac{\sigma}{\mu}$) are listed. The low - pass filtered curve (LOW PASS) within the time series plot is described by its minimum and maximum values. Finally, the maximum and minimum of the annual cycle (ANNUAL CYCLE) of the monthly means are listed with their relative standard deviations.

## 3.1 German Rivers

### 3.1.1 River Elbe

All data for the river Elbe were provided by the Arbeitsgemeinschaft für die Reinhaltung der Elbe (ARGE). The data are published in form of the annual publication series "Wassergütedaten der Elbe" and in papers on special issues. All documents are available under **www.fgg-elbe.de** in the internet.

The discharge data represent daily measurements from the last tide-free gauge station at Neu Darchau (km 536). Until 1991 the concentration data were selected from weekly samples at the site Teufelsbrück (km 630) just downstream of the Hamburg harbour; afterwards they stem from weekly samples at the sampling site Seemannshöft (km 628). At these stations the outlets of the big water treatment plant Köhlbrandshöft are not completely mixed with the Elbe water. Both sampling sites are well beyond the starting of the tidal mixing zone near Glückstadt (about km 674), which is characterized by the low chloride content of about 150 $mg/l$.

Before 1993 the nutrient data were derived from individual samples, whereas from 1994 onward the data are taken from horizontal profile mixing probes (Querprofilmischproben). The data for total phosphorus and total nitrogen start with the year 1978. Furthermore the technique of measuring Kjeldahl nitrogen was changed towards the measurement of Koroleff nitrogen which should lead to higher nitrogen values than the previous technique. However, no inhomogenity can be detected within the data presented here. Nitrite data were measured by ARGE also before 1990 but are not taken into account in this updated report. Silicate data were provided by ARGE for the sampling station Grauerort (km 660) starting in February 1988.

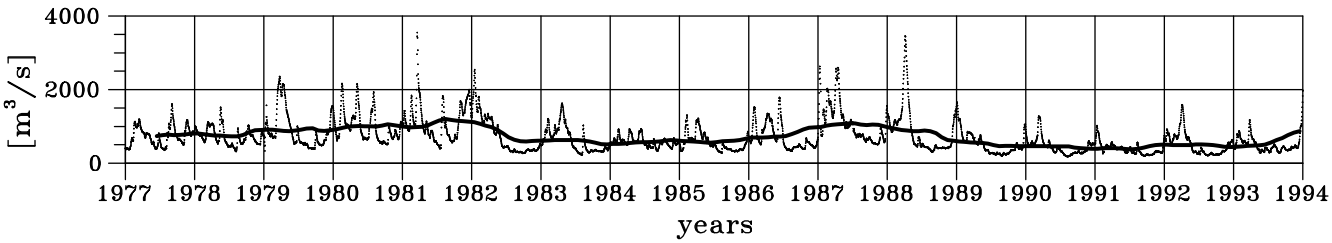
To the river discharge given at the tide-free gauge station Neu Darchau an amount of 21 % (pers. comm. Bergemann; ARGE) has to be added in order to take into account the additional drainage from the area downstream of Neu Darchau. As mentioned before this factor has not yet been used for the presented data within this volume.

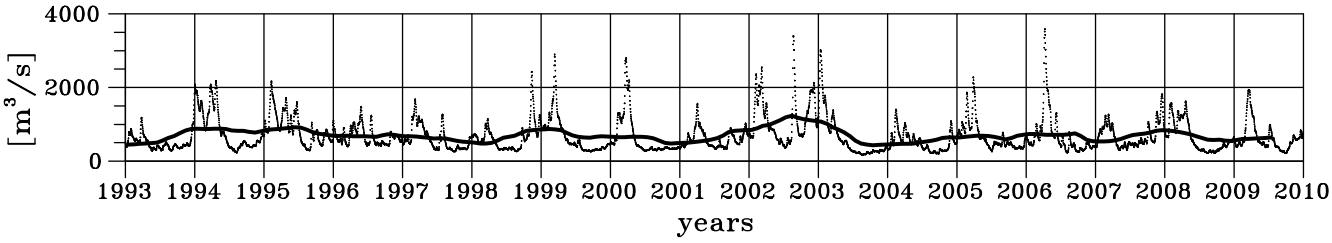
## Discharge from River Elbe

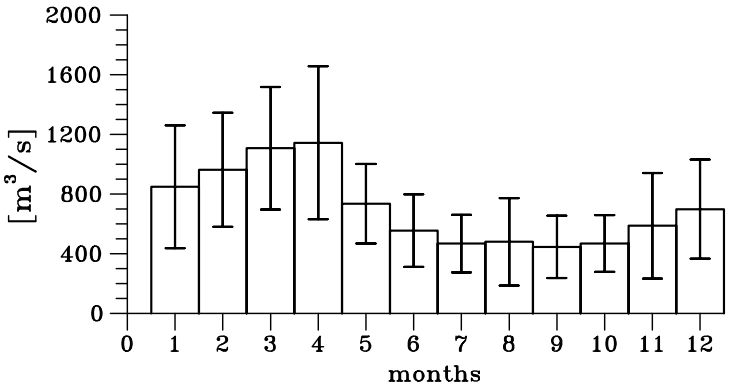
TIME SERIES
number of data: 12052
mean: 707 $m^3/s$
relative standard deviation: 0.64
minimum: 173 $m^3/s$ August 18, 2003
maximum: 3590 $m^3/s$ April 9, 2006

LOW PASS
minimum: 381 $m^3/s$ July 1991
maximum: 1229 $m^3/s$ August 2002

ANNUAL CYCLE
minimum: 445 $m^3/s$ September, rel. stdev: 0.47
maximum: 1144 $m^3/s$ April, rel. stdev: 0.45



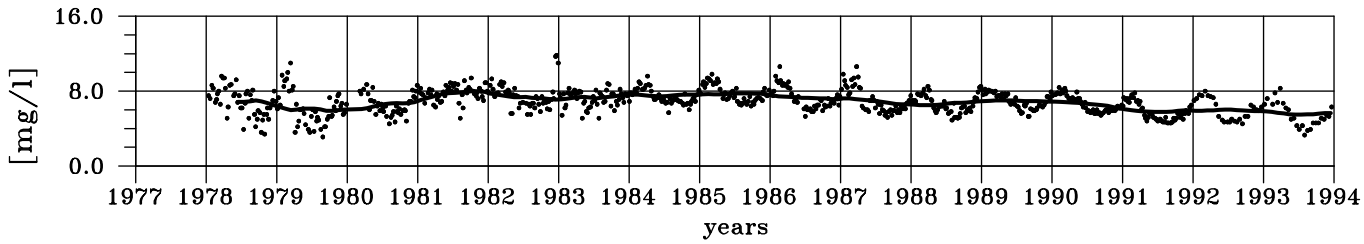



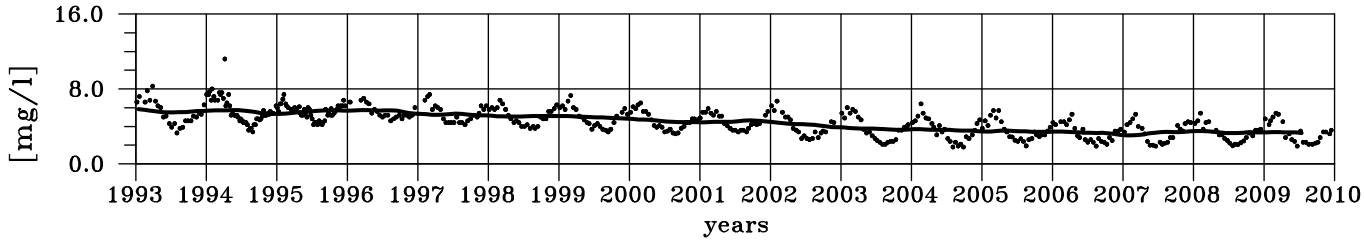
## Total Nitrogen from River Elbe

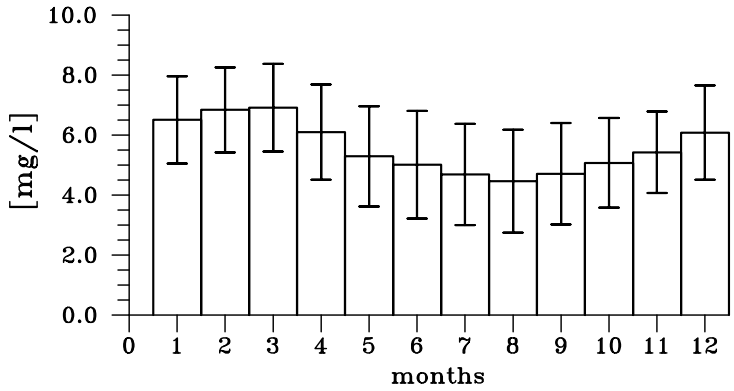
TIME SERIES
number of data: 1198
mean: 5.99 mg/l
relative standard deviation: 0.29
minimum: 1.80 mg/l August 3, 2004
maximum: 11.80 mg/l December 21, 1982

LOW PASS
minimum: 3.05 mg/l February 2007
maximum: 7.99 mg/l October 1981

ANNUAL CYCLE
minimum: 4.46 mg/l August, rel. stdev: 0.38
maximum: 6.91 mg/l March, rel. stdev: 0.21



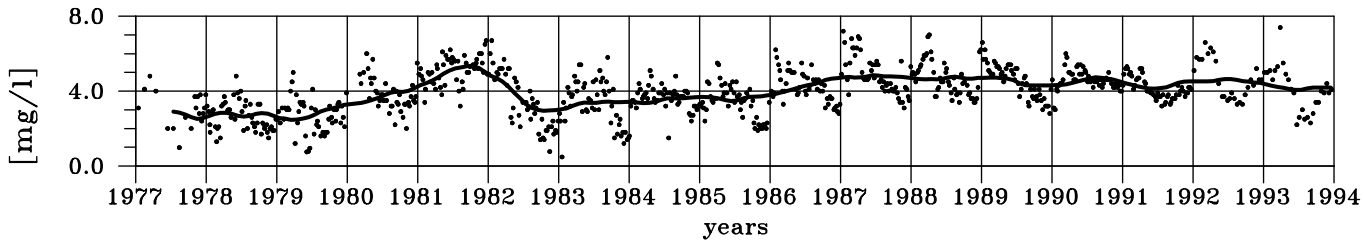



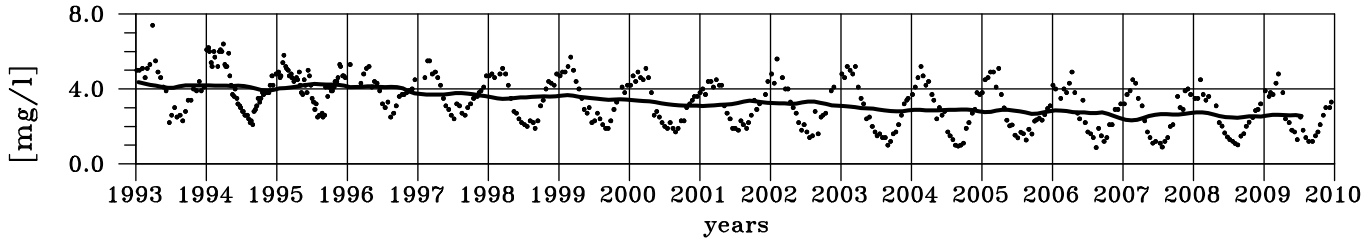
## Nitrate from River Elbe

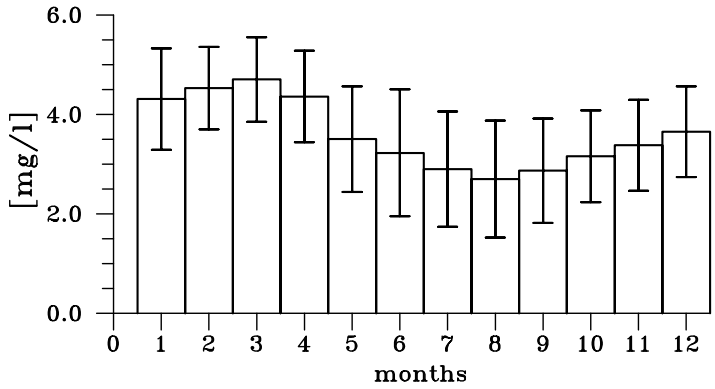
TIME SERIES
number of data: 1224
mean: 3.73 mg/l
relative standard deviation: 0.33
minimum: 0.48 mg/l January 18, 1983
maximum: 7.40 mg/l March 29, 1993

LOW PASS
minimum: 2.33 mg/l February 2007
maximum: 5.34 mg/l October 1981

ANNUAL CYCLE
minimum: 2.70 mg/l August, rel. stdev: 0.44
maximum: 4.70 mg/l March, rel. stdev: 0.18



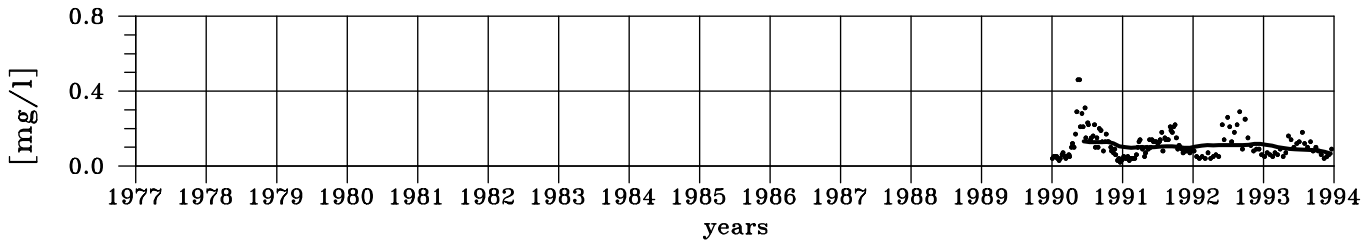



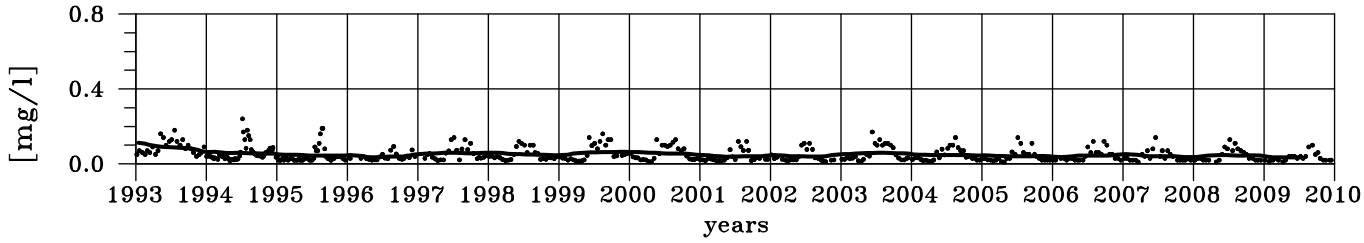
## Nitrite from River Elbe

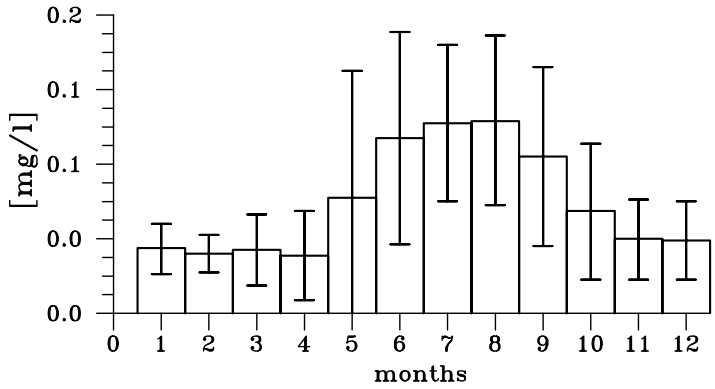
TIME SERIES
number of data: 600
mean: 0.06 mg/l
relative standard deviation: 0.87
minimum: 0.01 mg/l April 26, 2005
maximum: 0.46 mg/l May 15, 1990

LOW PASS
minimum: 0.03 mg/l March 2009
maximum: 0.13 mg/l June 1990

ANNUAL CYCLE
minimum: 0.03 mg/l April, rel. stdev: 0.79
maximum: 0.10 mg/l August, rel. stdev: 0.44



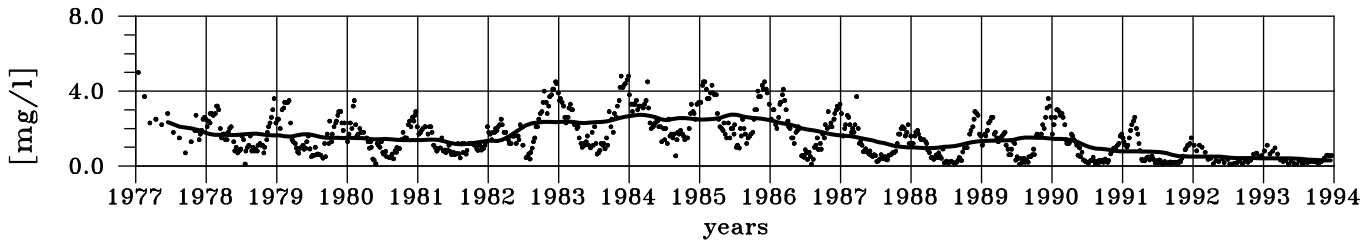



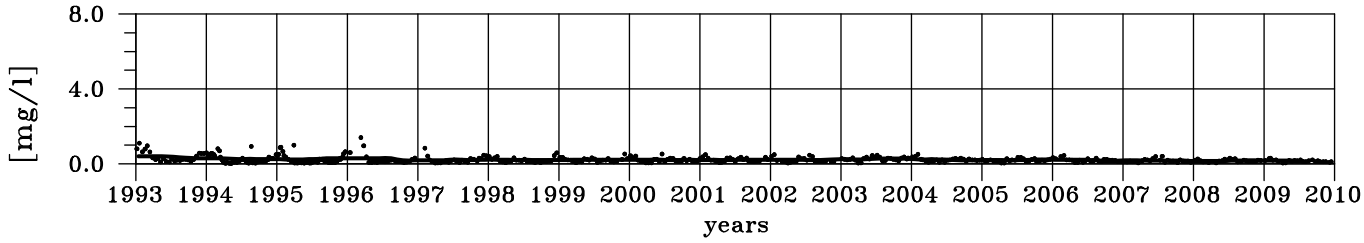
## Ammonium from River Elbe

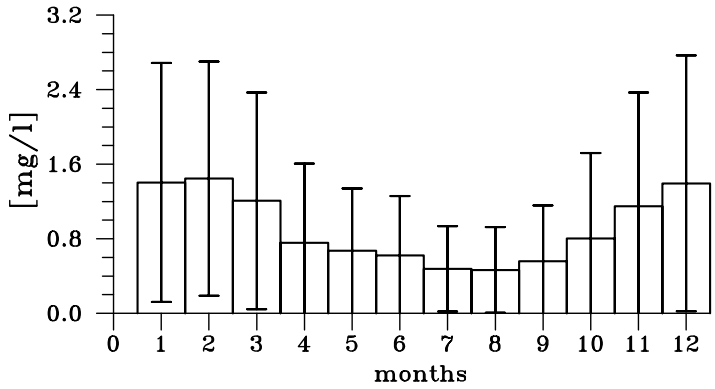
TIME SERIES
number of data: 1233
mean: 1.09 mg/l
relative standard deviation: 1.00
minimum: 0.02 mg/l May 9, 1994
maximum: 5.00 mg/l January 15, 1977

LOW PASS
minimum: 0.15 mg/l July 2009
maximum: 2.75 mg/l June 1985

ANNUAL CYCLE
minimum: 0.47 mg/l August, rel. stdev: 0.99
maximum: 1.45 mg/l February, rel. stdev: 0.87



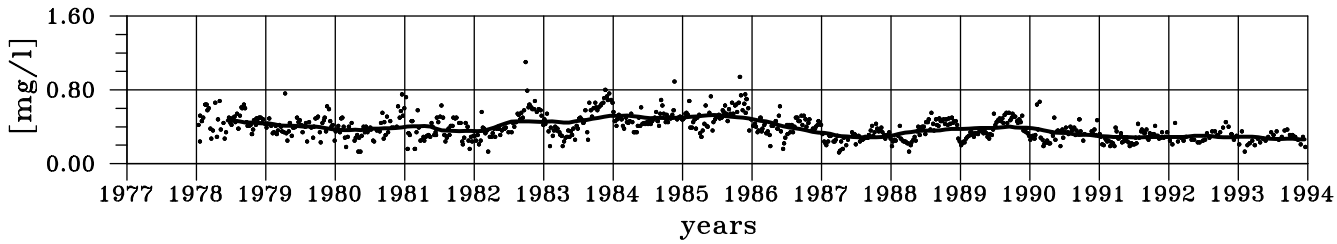



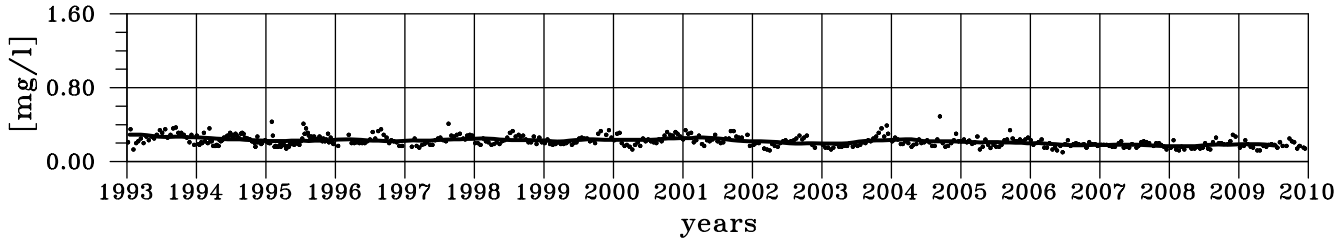
## Total Phosphorus from River Elbe

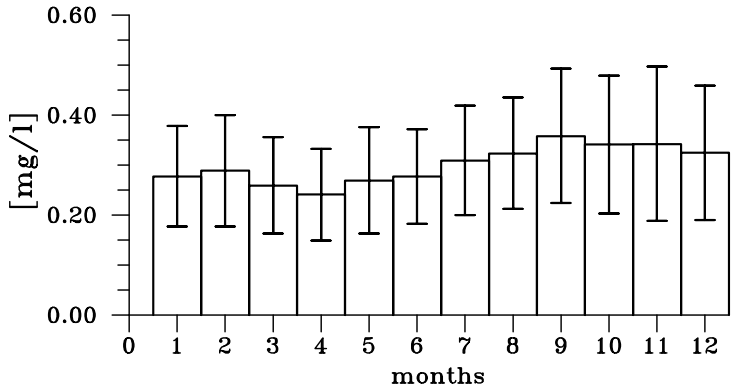
TIME SERIES
number of data: 1199
mean: 0.33 mg/l
relative standard deviation: 0.42
minimum: 0.10 mg/l June 19, 2006
maximum: 1.10 mg/l September 28, 1982

LOW PASS
minimum: 0.16 mg/l March 2008
maximum: 0.53 mg/l June 1985

ANNUAL CYCLE
minimum: 0.24 mg/l April, rel. stdev: 0.38
maximum: 0.36 mg/l September, rel. stdev: 0.38



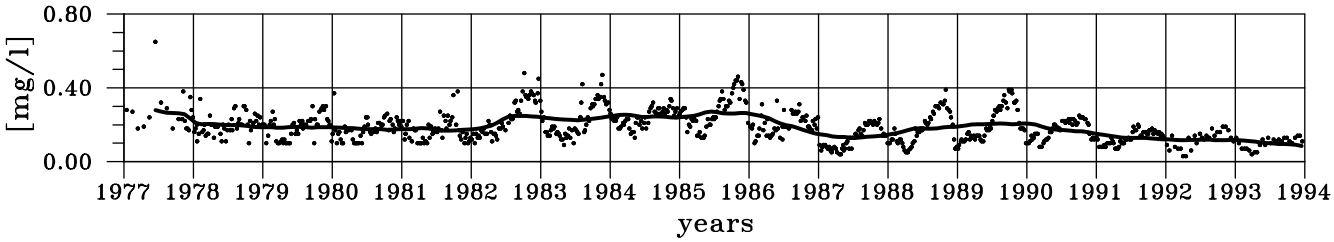



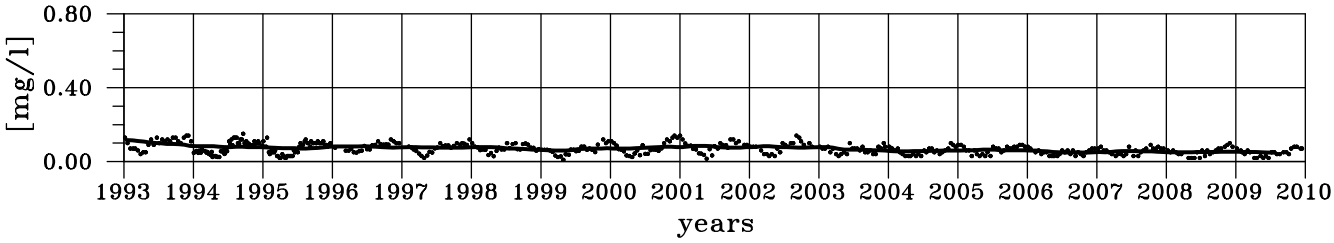
## Phosphate from River Elbe

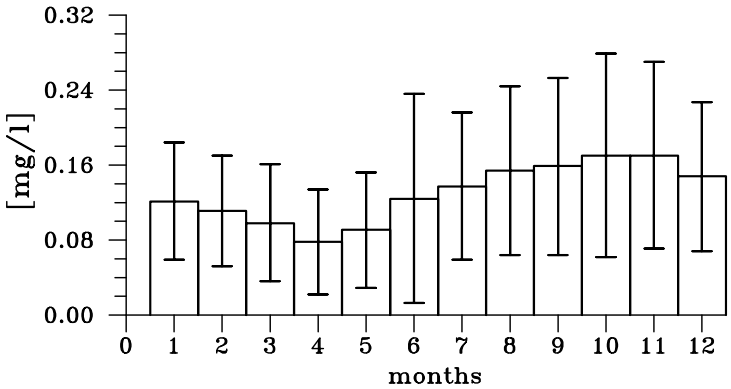
TIME SERIES
number of data: 1234
mean: 0.15 mg/l
relative standard deviation: 0.62
minimum: 0.01 mg/l April 29, 1999
maximum: 0.65 mg/l June 15, 1977

LOW PASS
minimum: 0.05 mg/l July 2009
maximum: 0.28 mg/l June 1977

ANNUAL CYCLE
minimum: 0.08 mg/l April, rel. stdev: 0.71
maximum: 0.17 mg/l October, rel. stdev: 0.64



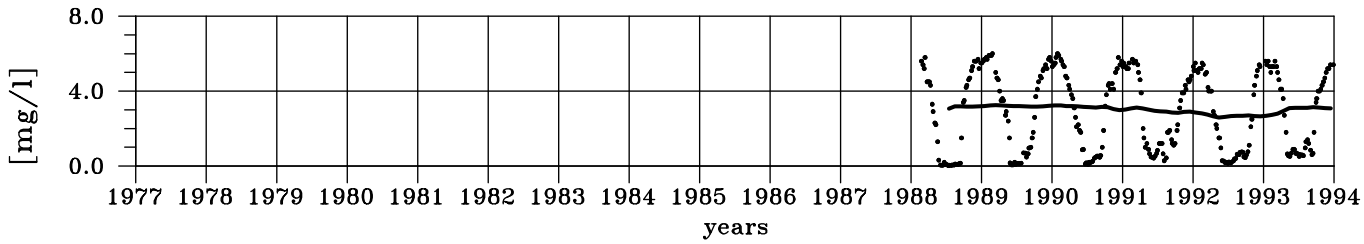



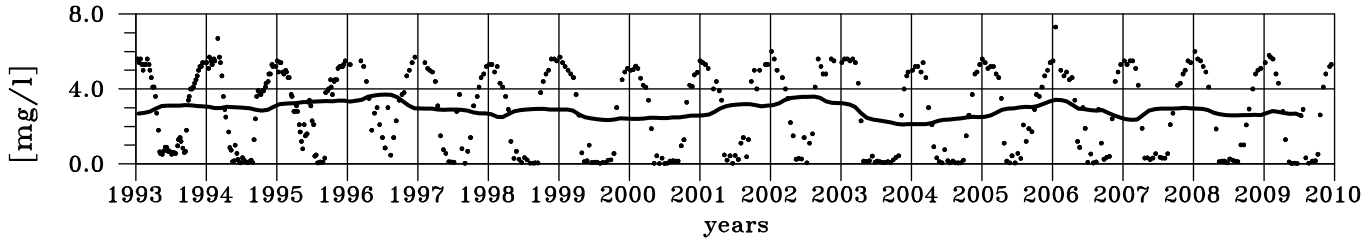
## Silicate from River Elbe

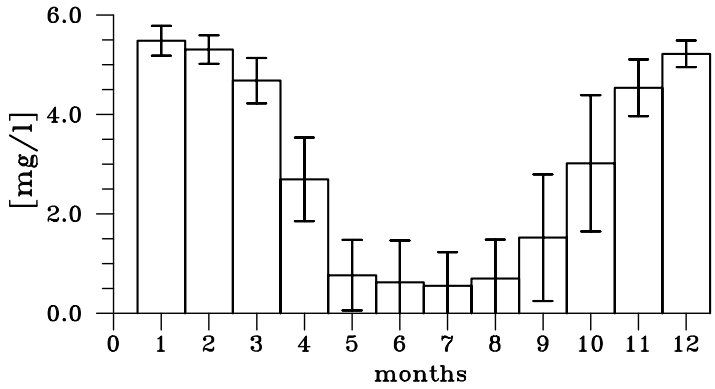
TIME SERIES
number of data: 740
mean: 2.86 mg/l
relative standard deviation: 0.74
minimum: 0.02 mg/l July 13, 1988
maximum: 7.30 mg/l January 17, 2006

LOW PASS
minimum: 2.10 mg/l November 2003
maximum: 3.70 mg/l July 1996

ANNUAL CYCLE
minimum: 0.56 mg/l July, rel. stdev: 1.21
maximum: 5.48 mg/l January, rel. stdev: 0.05



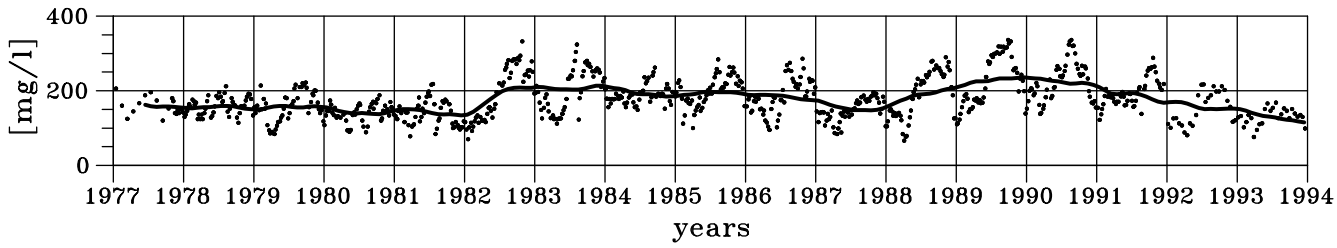



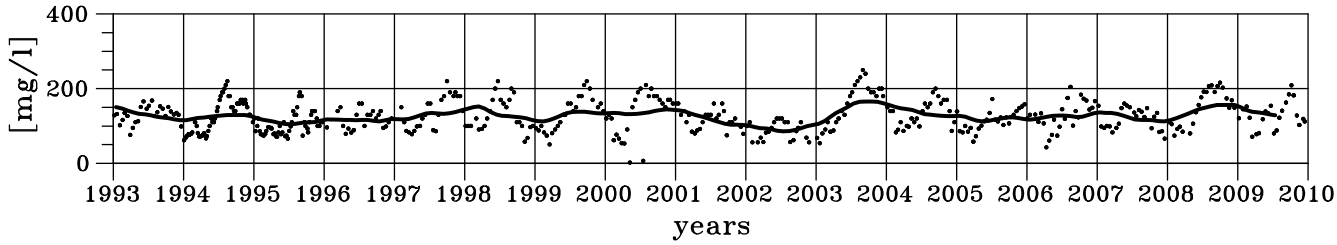
## Chloride from River Elbe

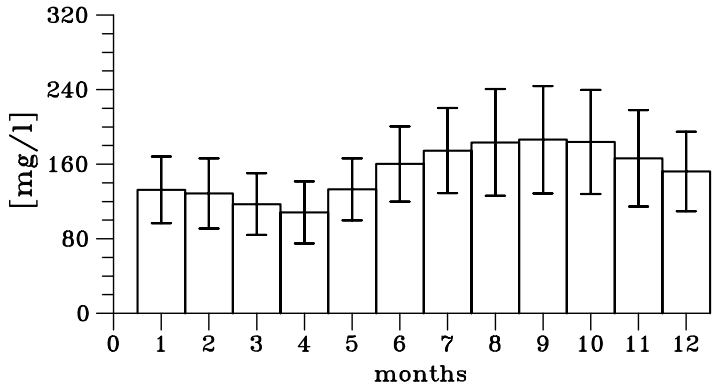
TIME SERIES
number of data: 1229
mean: 160 $mg/l$
relative standard deviation: 0.35
minimum: 2 $mg/l$ May 9, 2000
maximum: 336 $mg/l$ September 28, 1989

LOW PASS
minimum: 85 $mg/l$ July 2002
maximum: 236 $mg/l$ December 1989

ANNUAL CYCLE
minimum: 108 $mg/l$ April, rel. stdev: 0.31
maximum: 186 $mg/l$ September, rel. stdev: 0.31



### 3.1.2 River Weser

The daily flow data at the last tide-free gauge station for the river Weser at Intschede were provided by the Bundesanstalt für Gewässerkunde in Koblenz. The data are published in the yearly series of the "Deutsche Gewässerkundliche Jahrbücher", further information is available in the internet under www.bafg.de. The concentration data for the station Intschede for 1977 - 2006 and the station Uesen for 2007 - 2009 at the Weser were provided by the NLWKN in Hildesheim. Information on the data is published in "Gewässerüberwachungssystem Niedersachsen (GÜN) - Gütemeßnetz Fließgewässer.- Niedersächsisches Umweltministerium und Niedersächsisches Landesamt für Ökologie, Meßstrategie und Meßnetzkonzeption, 1998". Additional information is available under **www.nlwkn.de** in the internet.

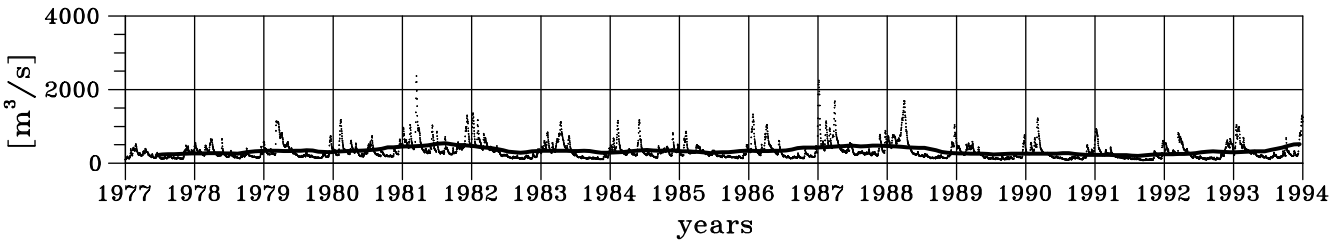
The concentration data cover the whole range from 1977 up to the end of 2009 for nitrate, ammonium and total phosphorus. Data on total nitrogen were available from 1980 and for orthophosphate from 1981 on. For this updated report nitrite and chloride were only taken into account from 1990 onward. For all these time series of nutrient concentrations there is only one value available for the year 1993. In contrast, silicate data were available at the measuring site Brake for the years 1993 and 1994 only. An amount of 19 % of discharge has to be added to the actual discharge data at the station Intschede (pers. comm. Berger, LfÖ) to get an improved estimate of the discharge entering the North Sea.

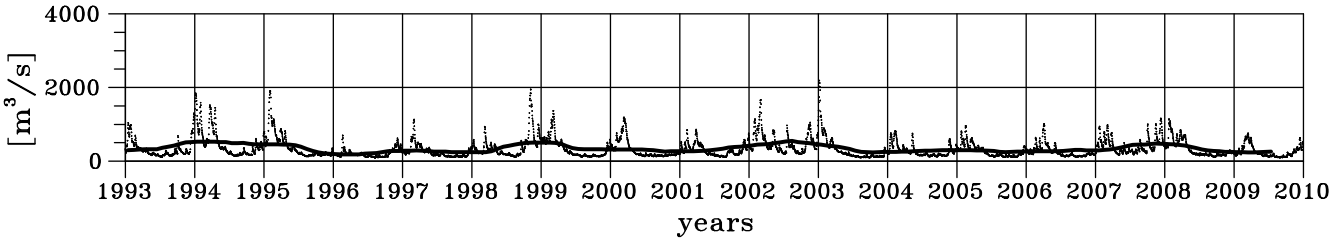
## Discharge from River Weser

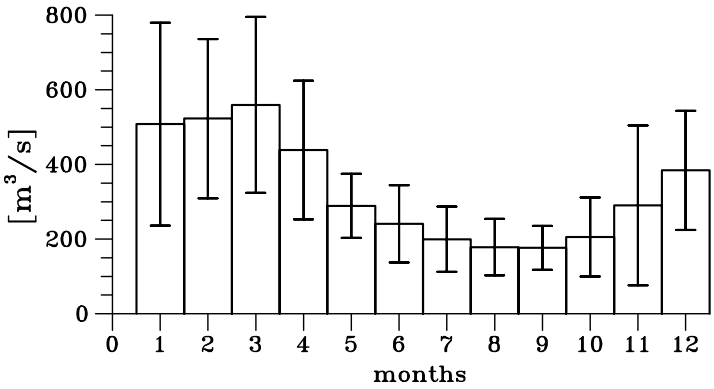
TIME SERIES
number of data: 12053
mean: 332 $m^3/s$
relative standard deviation: 0.75
minimum: 74 $m^3/s$ September 11, 1991
maximum: 2370 $m^3/s$ March 16, 1981

LOW PASS
minimum: 179 $m^3/s$ April 1996
maximum: 552 $m^3/s$ August 2002

ANNUAL CYCLE
minimum: 176 $m^3/s$ September, rel. stdev: 0.33
maximum: 560 $m^3/s$ March, rel. stdev: 0.42



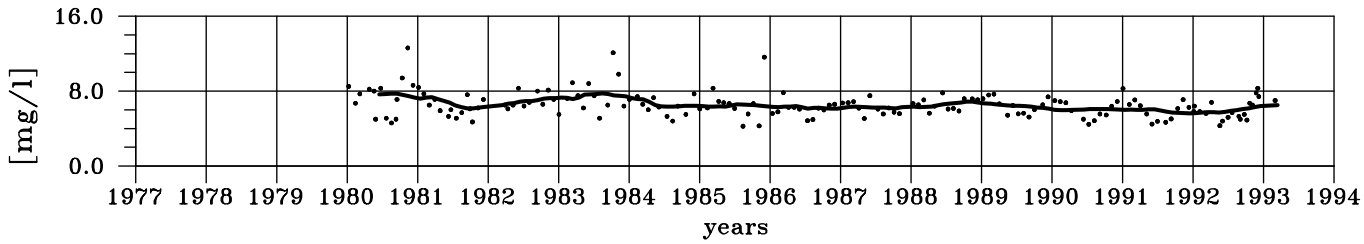



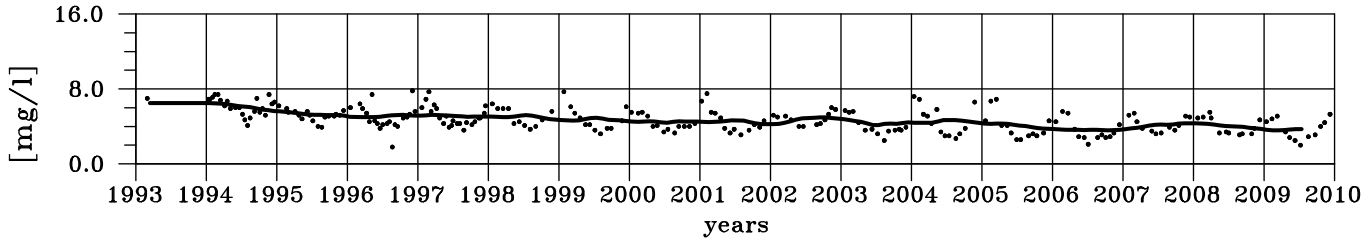
## Total Nitrogen from River Weser

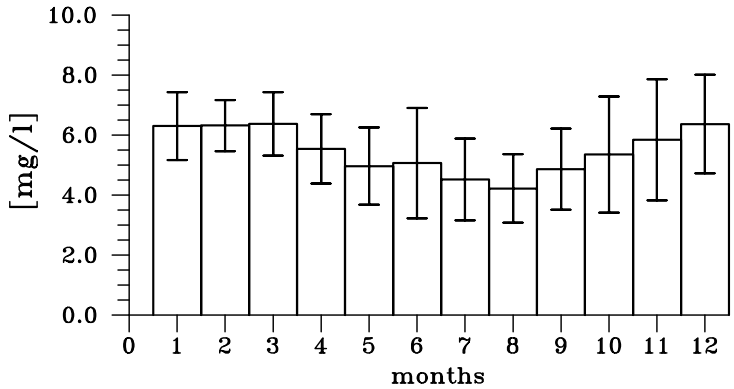
TIME SERIES
number of data: 393
mean: 5.44 mg/l
relative standard deviation: 0.29
minimum: 1.80 mg/l August 21, 1996
maximum: 12.60 mg/l November 10, 1980

LOW PASS
minimum: 3.57 mg/l March 2009
maximum: 7.77 mg/l August 1983

ANNUAL CYCLE
minimum: 4.22 mg/l August, rel. stdev: 0.27
maximum: 6.37 mg/l March, rel. stdev: 0.17



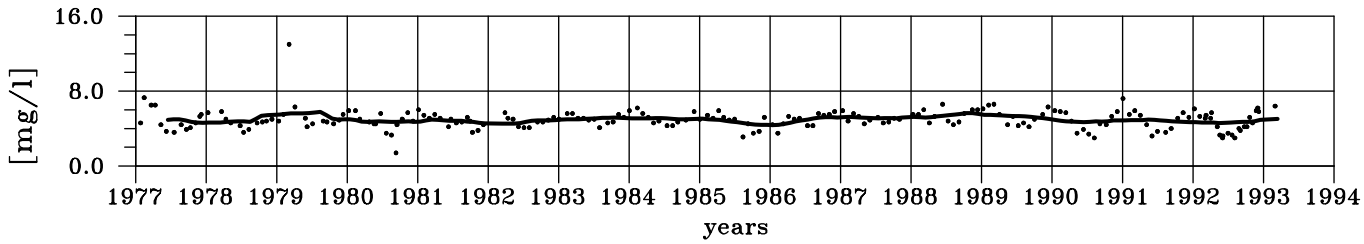



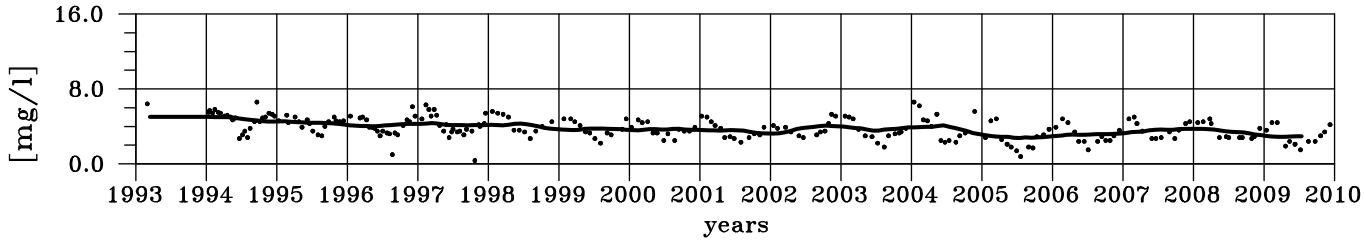
## Nitrate from River Weser

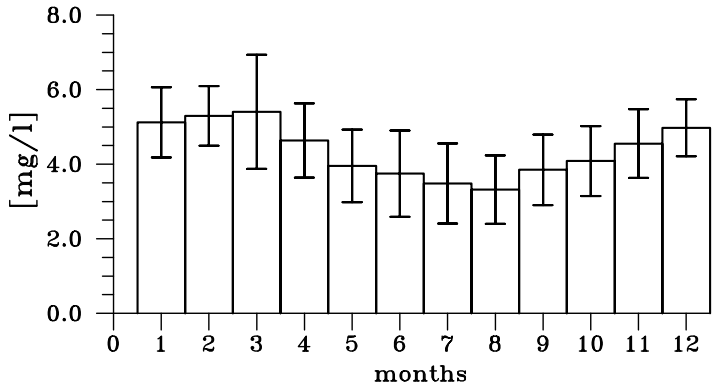
TIME SERIES
number of data: 435
mean: 4.33 mg/l
relative standard deviation: 0.28
minimum: 0.35 mg/l October 23, 1997
maximum: 13.00 mg/l March 5, 1979

LOW PASS
minimum: 2.75 mg/l July 2005
maximum: 5.76 mg/l August 1979

ANNUAL CYCLE
minimum: 3.32 mg/l August, rel. stdev: 0.28
maximum: 5.40 mg/l March, rel. stdev: 0.28



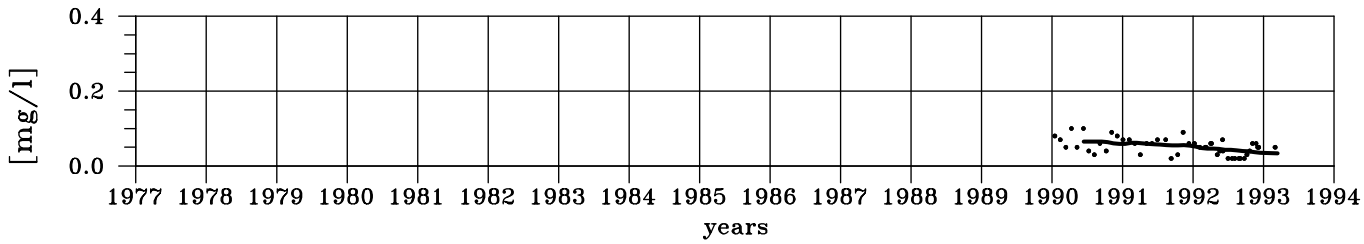



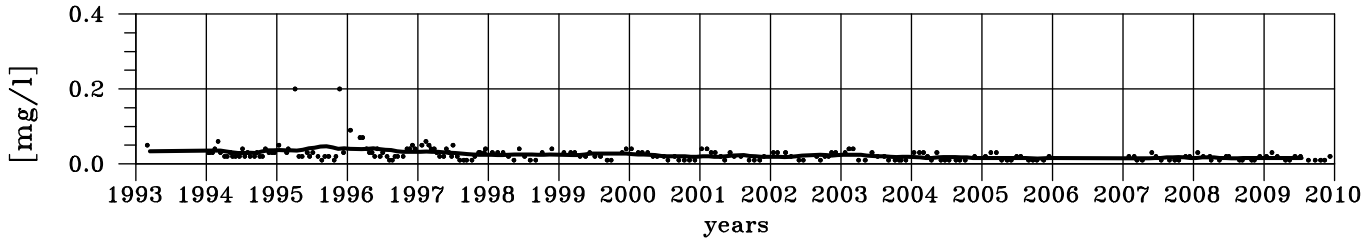
## Nitrite from River Weser

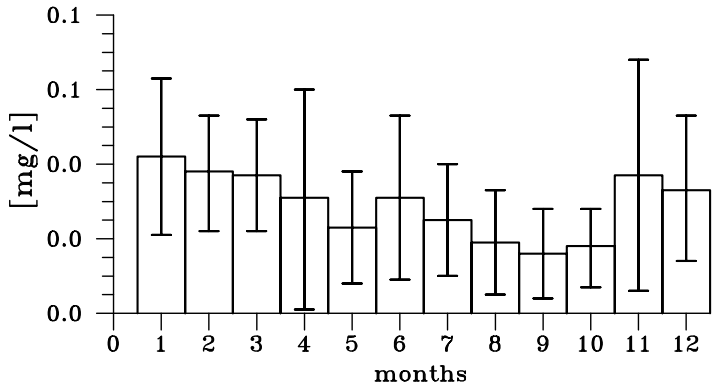
TIME SERIES
number of data: 266
mean: 0.03 mg/l
relative standard deviation: 0.80
minimum: 0.01 mg/l August 22, 1995
maximum: 0.20 mg/l April 5, 1995

LOW PASS
minimum: 0.01 mg/l October 2005
maximum: 0.07 mg/l September 1990

ANNUAL CYCLE
minimum: 0.02 mg/l September, rel. stdev: 0.77
maximum: 0.04 mg/l January, rel. stdev: 0.50



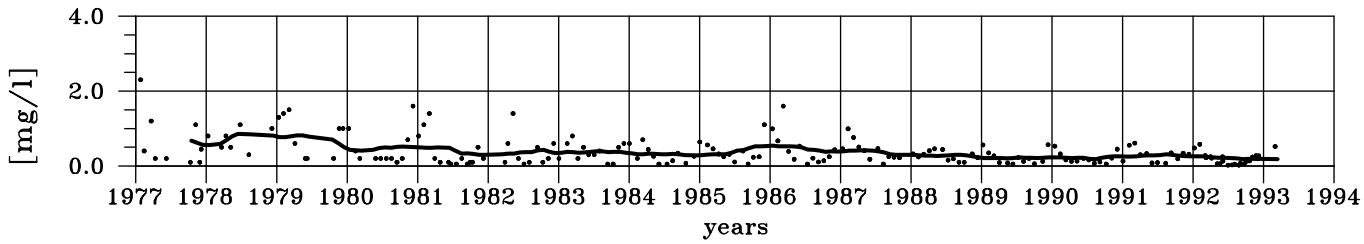



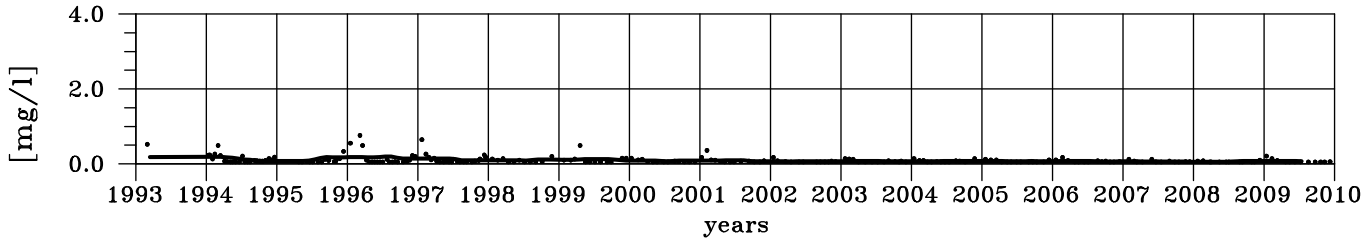
## Ammonium from River Weser

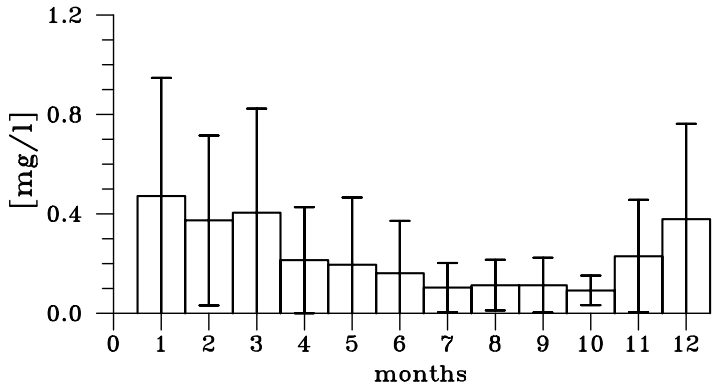
TIME SERIES
number of data: 417
mean: 0.22 mg/l
relative standard deviation: 1.31
minimum: 0.02 mg/l July 1, 1992
maximum: 2.30 mg/l January 26, 1977

LOW PASS
minimum: 0.06 mg/l May 2008
maximum: 0.85 mg/l June 1978

ANNUAL CYCLE
minimum: 0.09 mg/l October, rel. stdev: 0.64
maximum: 0.47 mg/l January, rel. stdev: 1.00



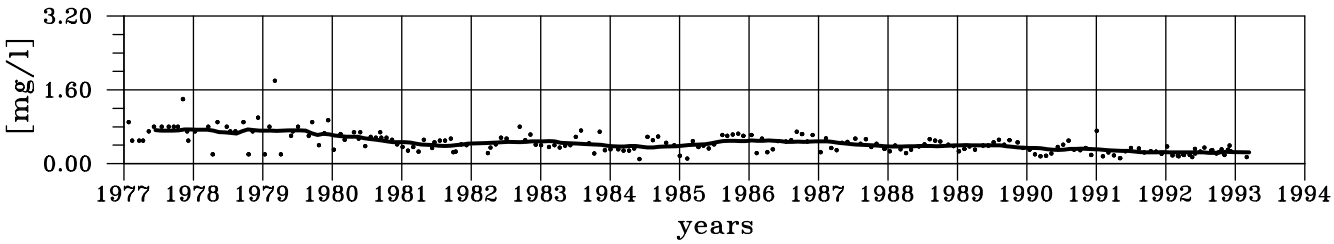



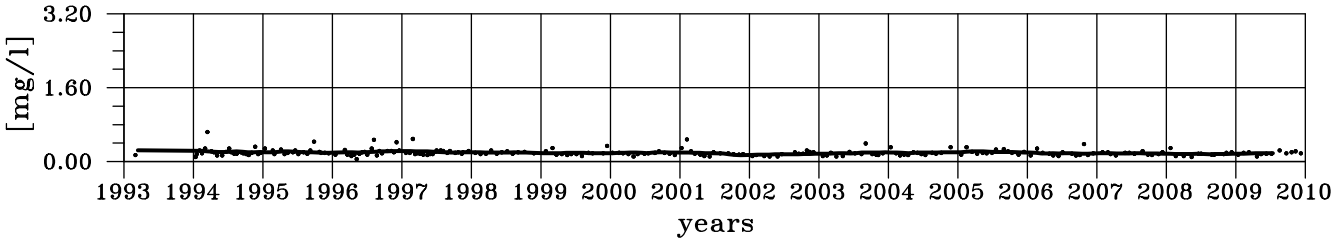
## Total Phosphorus from River Weser

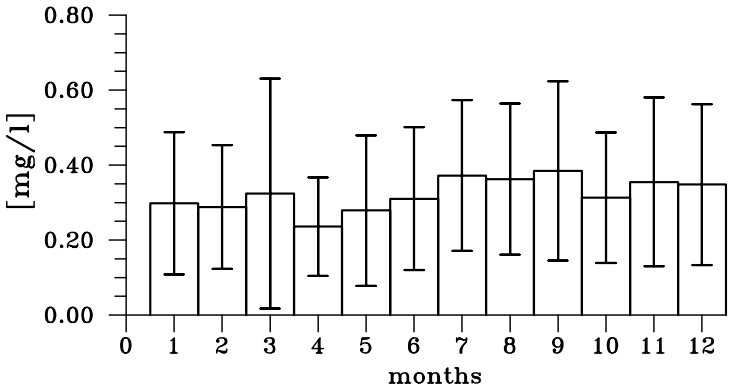
TIME SERIES
number of data: 433
mean: 0.31 mg/l
relative standard deviation: 0.66
minimum: 0.05 mg/l May 8, 1996
maximum: 1.80 mg/l March 5, 1979

LOW PASS
minimum: 0.14 mg/l November 2001
maximum: 0.74 mg/l November 1977

ANNUAL CYCLE
minimum: 0.24 mg/l April, rel. stdev: 0.56
maximum: 0.38 mg/l September, rel. stdev: 0.62



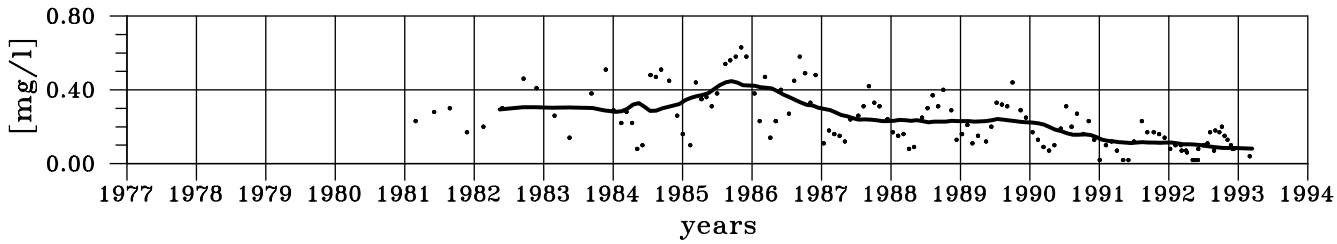



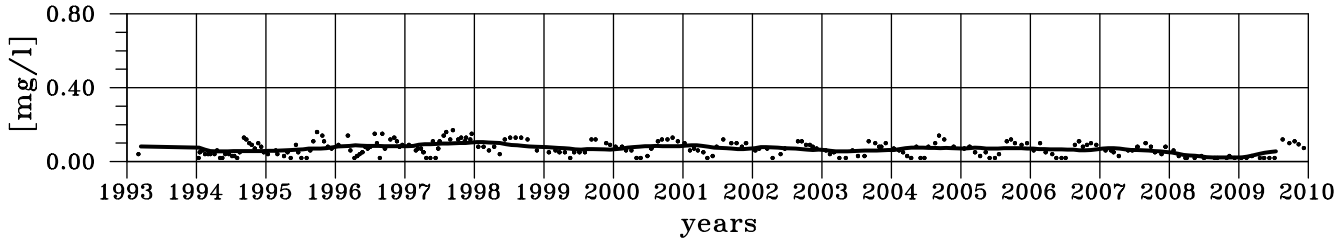
## Phosphate from River Weser

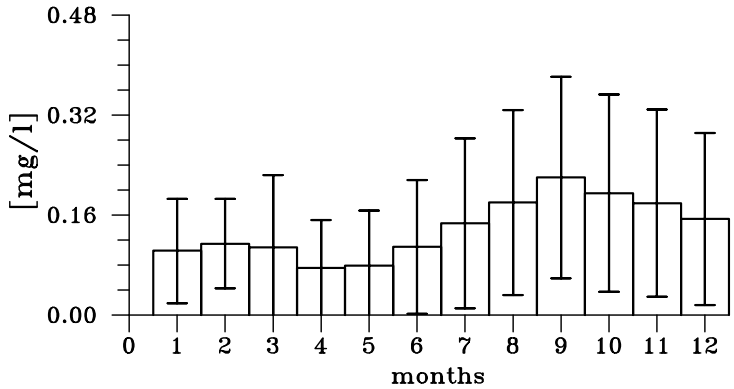
TIME SERIES
number of data: 361
mean: 0.13 mg/l
relative standard deviation: 0.95
minimum: 0.02 mg/l January 3, 1991
maximum: 0.63 mg/l November 5, 1985

LOW PASS
minimum: 0.02 mg/l January 2009
maximum: 0.45 mg/l September 1985

ANNUAL CYCLE
minimum: 0.08 mg/l April, rel. stdev: 1.01
maximum: 0.22 mg/l September, rel. stdev: 0.73



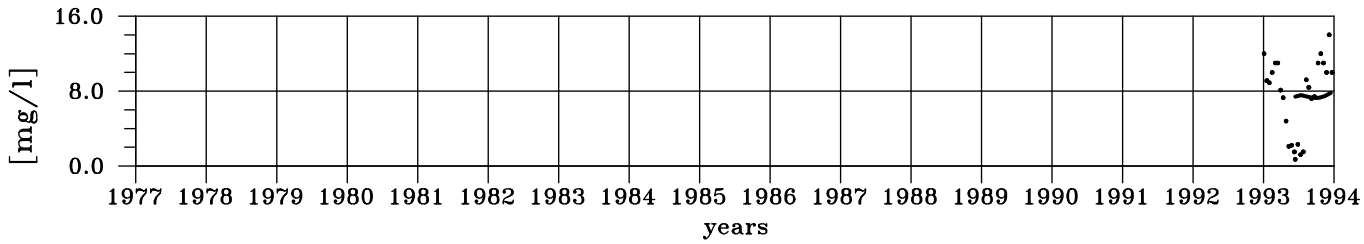



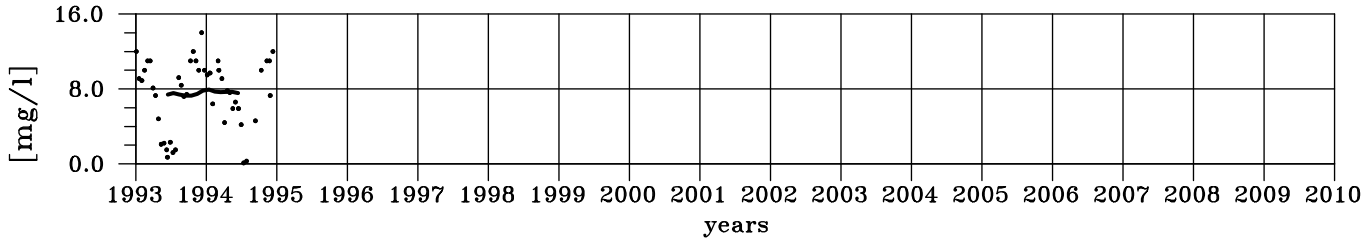
## Silicate from River Weser

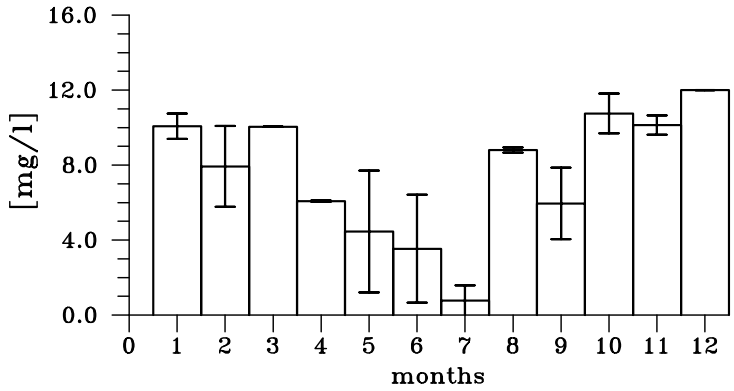
TIME SERIES
number of data: 47
mean: 7.41 mg/l
relative standard deviation: 0.50
minimum: 0.10 mg/l July 14, 1994
maximum: 14.00 mg/l December 7, 1993

LOW PASS
minimum: 7.27 mg/l September 1993
maximum: 7.94 mg/l January 1994

ANNUAL CYCLE
minimum: 0.78 mg/l July, rel. stdev: 1.05
maximum: 12.00 mg/l December, rel. stdev: 0.00



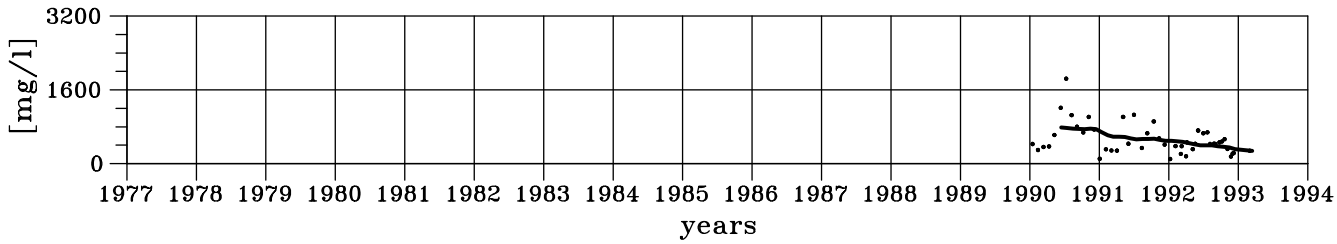



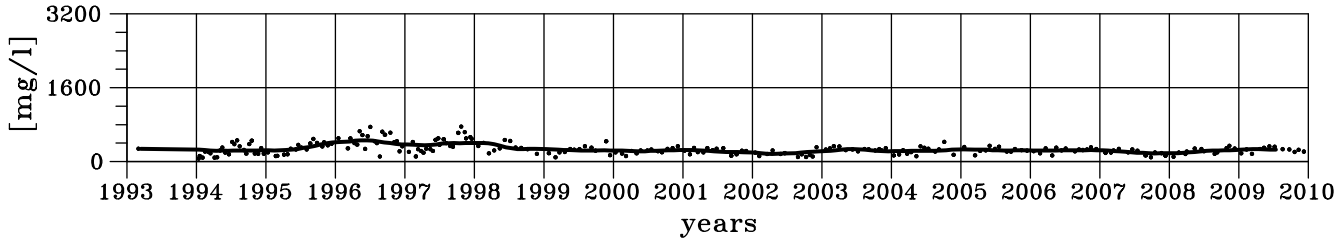
## Chloride from River Weser

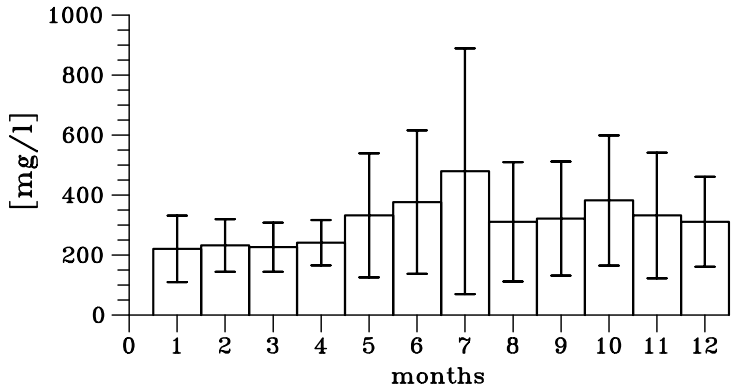
TIME SERIES
number of data: 278
mean: 317 $mg/l$
relative standard deviation: 0.64
minimum: 63 $mg/l$ January 12, 1994
maximum: 1840 $mg/l$ July 10, 1990

LOW PASS
minimum: 162 $mg/l$ April 2002
maximum: 785 $mg/l$ June 1990

ANNUAL CYCLE
minimum: 220 $mg/l$ January, rel. stdev: 0.50
maximum: 479 $mg/l$ July, rel. stdev: 0.86



### 3.1.3 River Ems

The daily flow data at the last tide-free gauge station for the river Ems at Herbrum were provided by the Bundesanstalt für Gewässerkunde in Koblenz. The data are published in the yearly series of the "Deutsche Gewässerkundliche Jahrbücher", further information is available in the internet under www.bafg.de. The concentration data for the station Herbrum at the Ems were provided by the NLWKN in Hildesheim. Information on the data is published in "Gewässerüberwachungssystem Niedersachsen (GÜN) - Gütemeßnetz Fließgewässer.- Niedersächsisches Umweltministerium und Niedersächsisches Landesamt für Ökologie, Meßstrategie und Meßnetzkonzeption, 1998". Additional information is available under **www.nlwkn.de** in the internet.

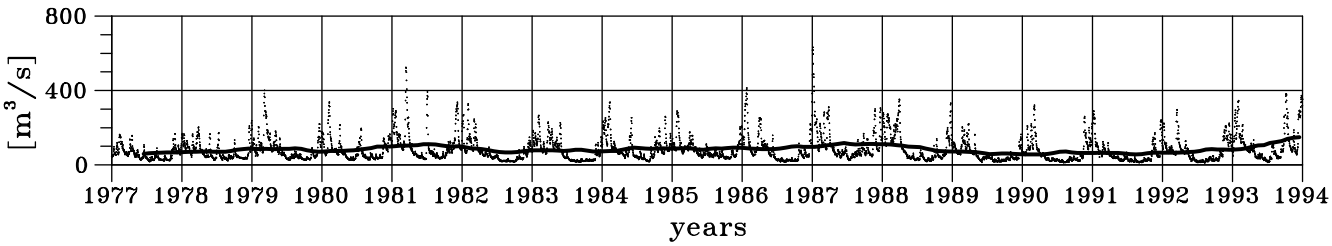
The concentration data cover the whole range from 1977 up to the end of 2009 for nitrate, ammonium and total phosphorus. Data on total nitrogen were available from 1980 and for orthophosphate from 1981 on. For this updated report data on nitrite and chloride were only taken into account from 1990 onward. Silicate data were available for the years 1989 and 1994 at the measuring site Terborg. These data stem from a different measuring program. An amount of 30 % of discharge has to be added to the actual discharge data at the station Herbrum (pers. comm. Berger, LfÖ) to get an improved estimate of the discharge which also regards the contributions downstream of the gauge station.

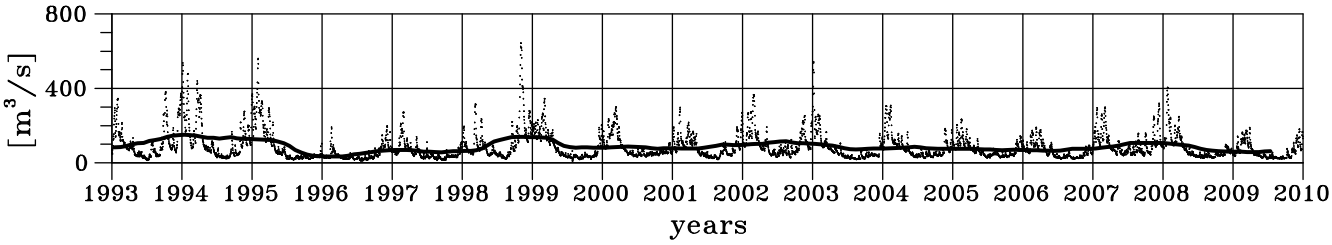
## Discharge from River Ems

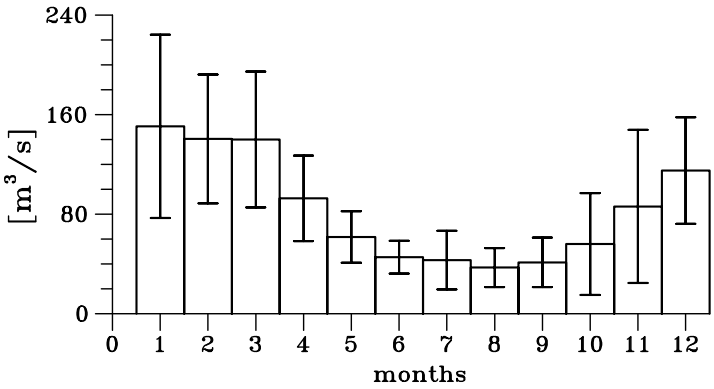
TIME SERIES
number of data: 12053
mean: 84 $m^3/s$
relative standard deviation: 0.85
minimum: 11 $m^3/s$ July 30, 1999
maximum: 643 $m^3/s$ November 3, 1998

LOW PASS
minimum: 34 $m^3/s$ March 1996
maximum: 150 $m^3/s$ January 1994

ANNUAL CYCLE
minimum: 37 $m^3/s$ August, rel. stdev: 0.42
maximum: 151 $m^3/s$ January, rel. stdev: 0.49



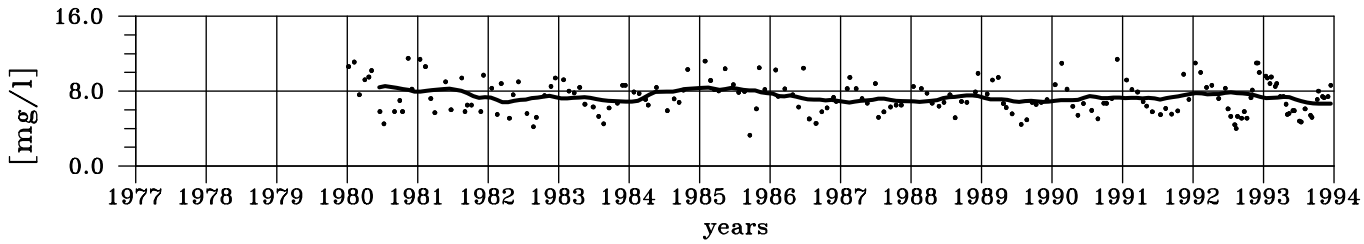



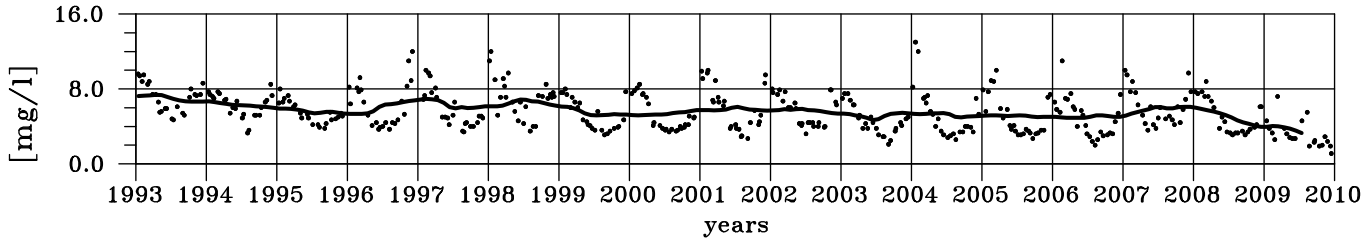
## Total Nitrogen from River Ems

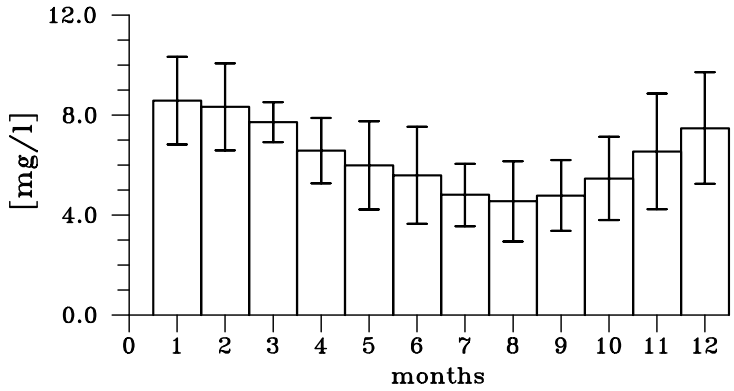
TIME SERIES
number of data: 580
mean: 6.09 mg/l
relative standard deviation: 0.36
minimum: 1.10 mg/l December 15, 2009
maximum: 13.00 mg/l January 22, 2004

LOW PASS
minimum: 3.30 mg/l July 2009
maximum: 8.54 mg/l July 1980

ANNUAL CYCLE
minimum: 4.55 mg/l August, rel. stdev: 0.35
maximum: 8.58 mg/l January, rel. stdev: 0.20



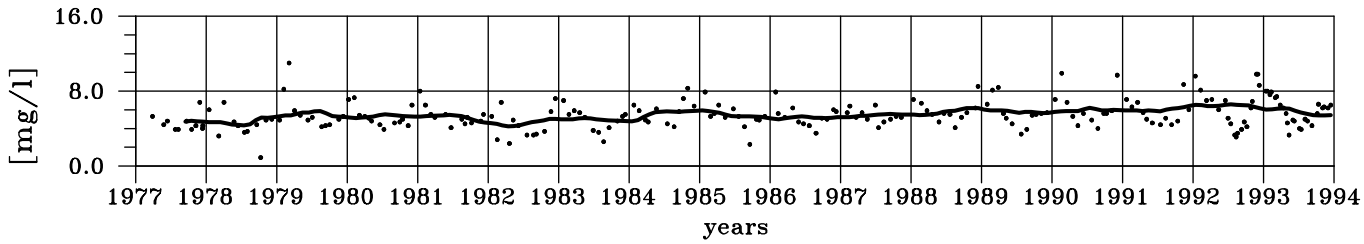



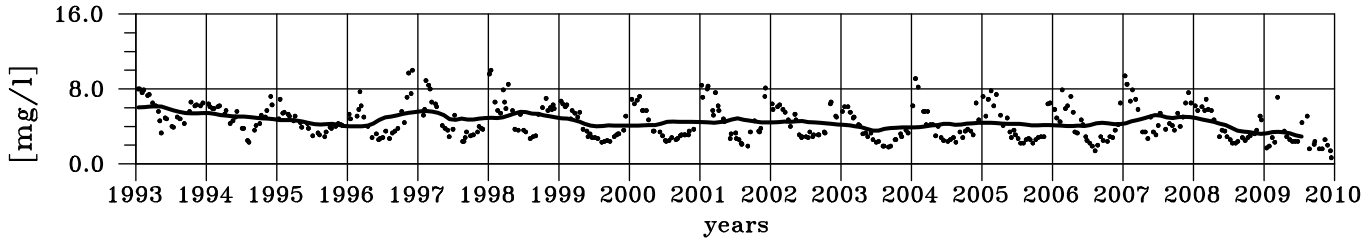
## Nitrate from River Ems

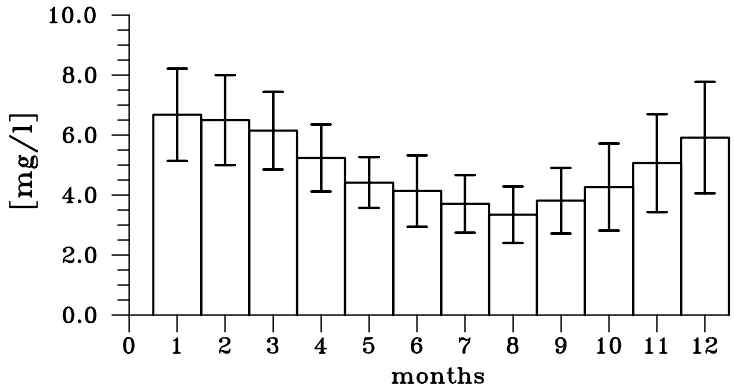
TIME SERIES
number of data: 616
mean: 4.77 mg/l
relative standard deviation: 0.37
minimum: 0.65 mg/l December 15, 2009
maximum: 11.00 mg/l March 6, 1979

LOW PASS
minimum: 2.92 mg/l July 2009
maximum: 6.60 mg/l July 1992

ANNUAL CYCLE
minimum: 3.34 mg/l August, rel. stdev: 0.28
maximum: 6.68 mg/l January, rel. stdev: 0.23



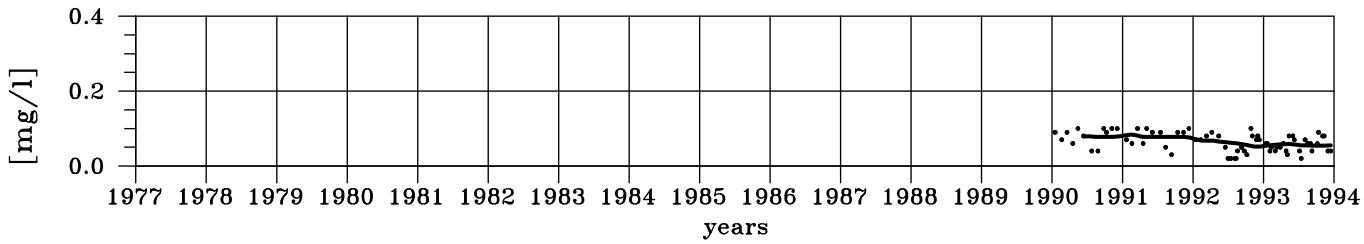



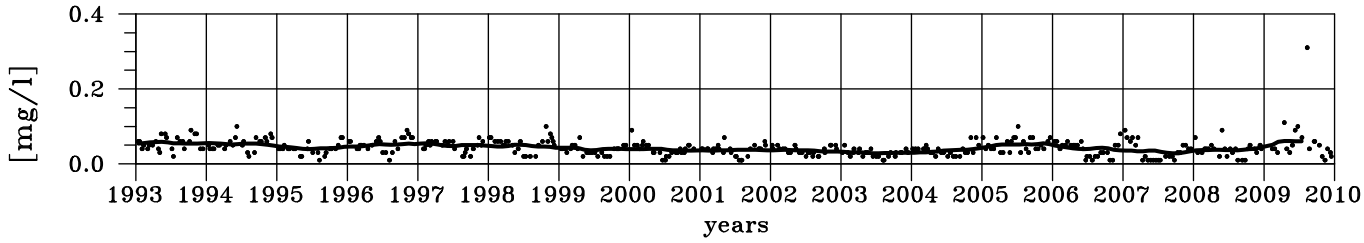
## Nitrite from River Ems

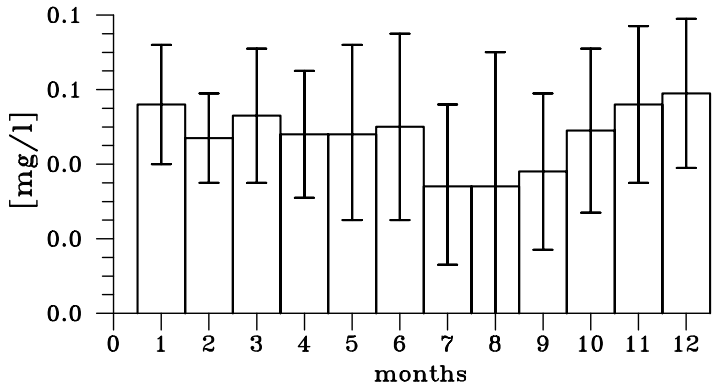
TIME SERIES
number of data: 461
mean: 0.05 mg/l
relative standard deviation: 0.54
minimum: 0.01 mg/l August 9, 1995
maximum: 0.31 mg/l August 13, 2009

LOW PASS
minimum: 0.03 mg/l July 2003
maximum: 0.08 mg/l February 1991

ANNUAL CYCLE
minimum: 0.03 mg/l August, rel. stdev: 1.03
maximum: 0.06 mg/l December, rel. stdev: 0.33



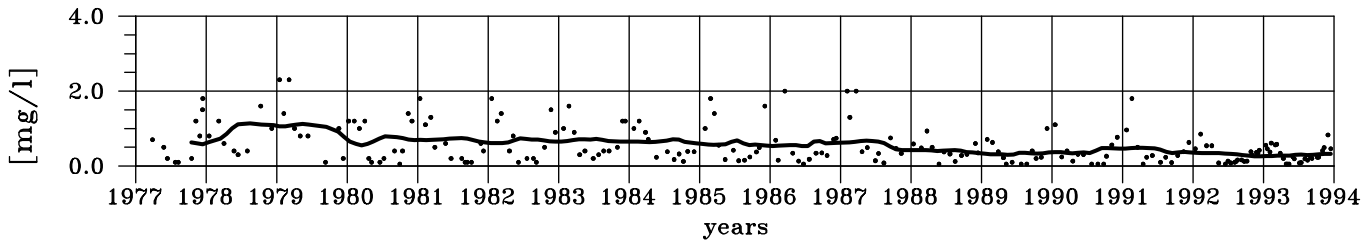



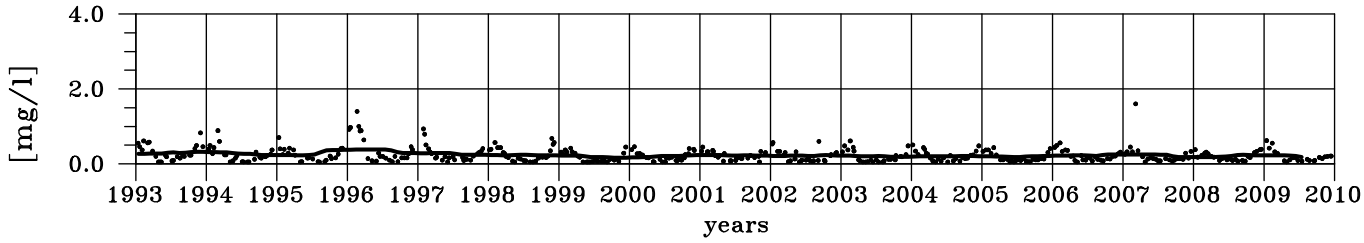
## Ammonium from River Ems

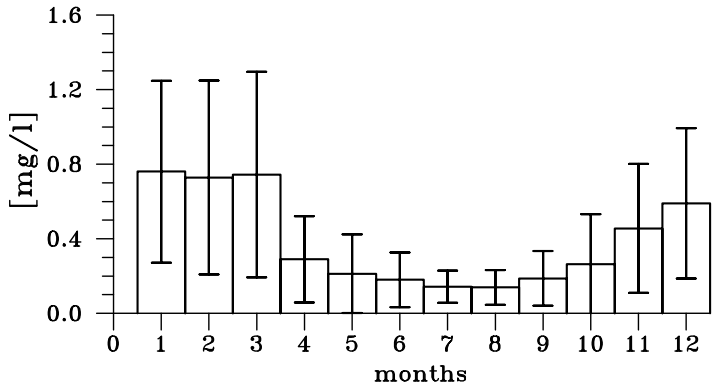
TIME SERIES
number of data: 611
mean: 0.34 mg/l
relative standard deviation: 1.07
minimum: 0.05 mg/l September 30, 1980
maximum: 2.30 mg/l January 16, 1979

LOW PASS
minimum: 0.17 mg/l November 1999
maximum: 1.14 mg/l August 1978

ANNUAL CYCLE
minimum: 0.14 mg/l August, rel. stdev: 0.67
maximum: 0.76 mg/l January, rel. stdev: 0.64



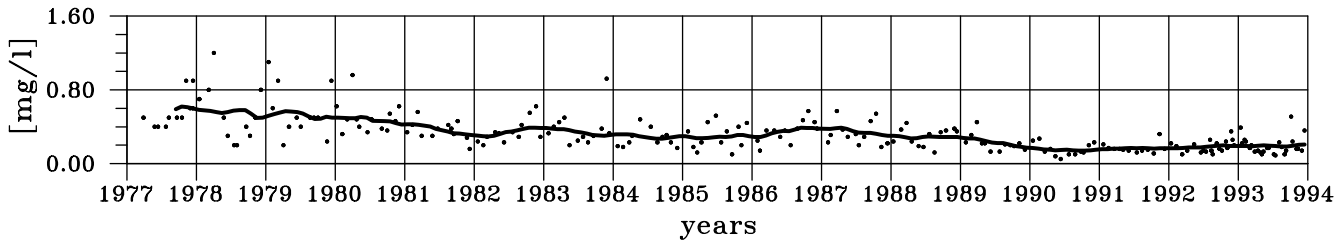



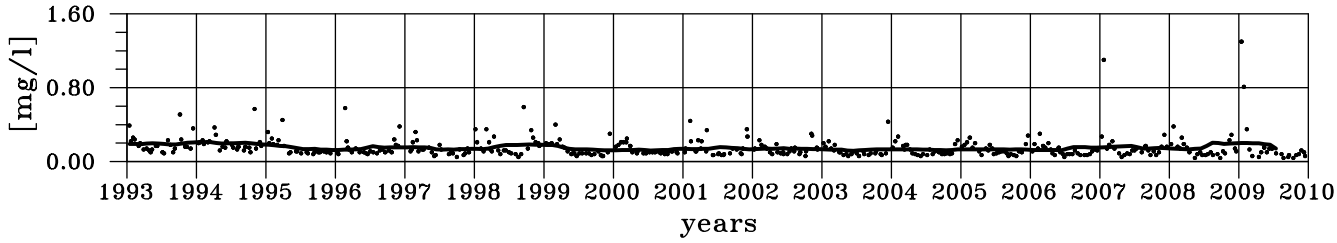
## Total Phosphorus from River Ems

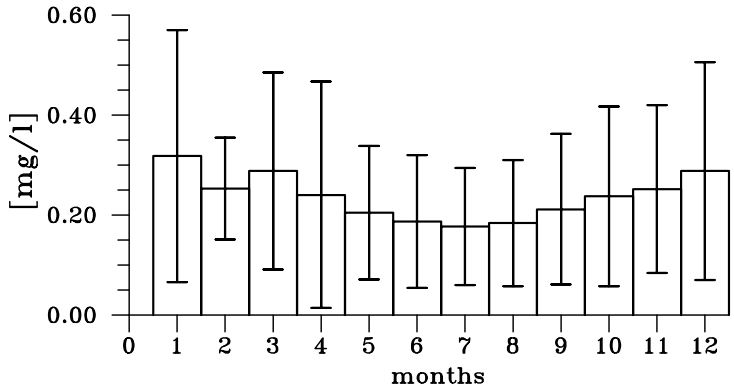
TIME SERIES
number of data: 619
mean: 0.21 mg/l
relative standard deviation: 0.81
minimum: 0.04 mg/l May 15, 2008
maximum: 1.30 mg/l January 15, 2009

LOW PASS
minimum: 0.12 mg/l June 2003
maximum: 0.62 mg/l October 1977

ANNUAL CYCLE
minimum: 0.18 mg/l July, rel. stdev: 0.66
maximum: 0.32 mg/l January, rel. stdev: 0.79



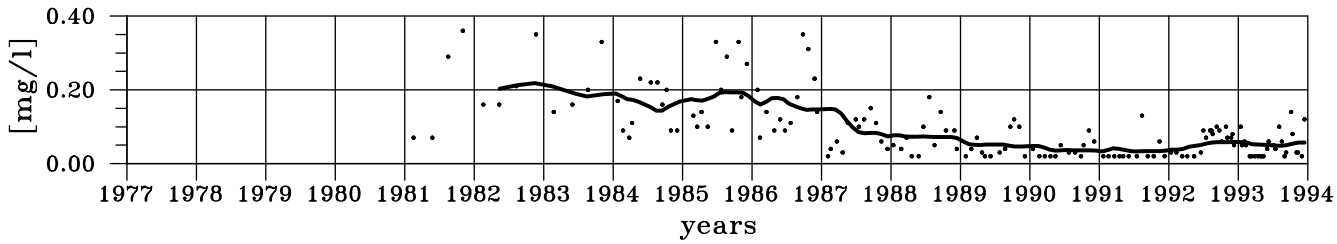



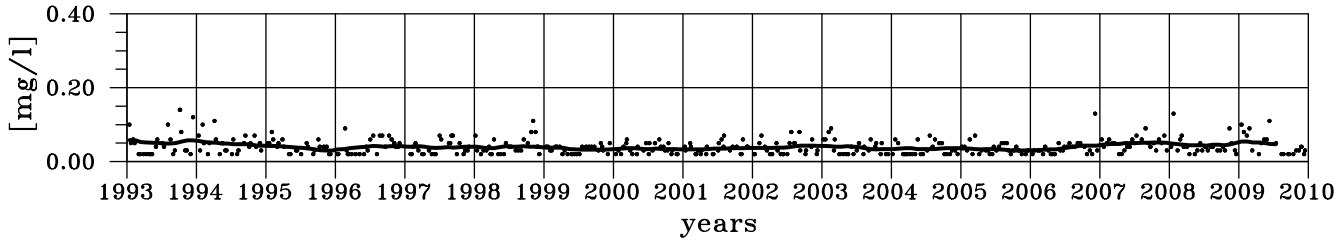
## Phosphate from River Ems

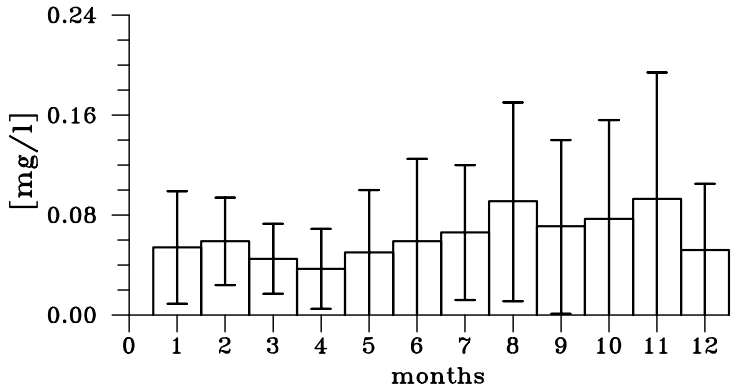
TIME SERIES
number of data: 546
mean: 0.05 mg/l
relative standard deviation: 0.97
minimum: 0.02 mg/l February 4, 1987
maximum: 0.36 mg/l November 2, 1981

LOW PASS
minimum: 0.03 mg/l October 2005
maximum: 0.22 mg/l November 1982

ANNUAL CYCLE
minimum: 0.04 mg/l April, rel. stdev: 0.85
maximum: 0.09 mg/l November, rel. stdev: 1.09



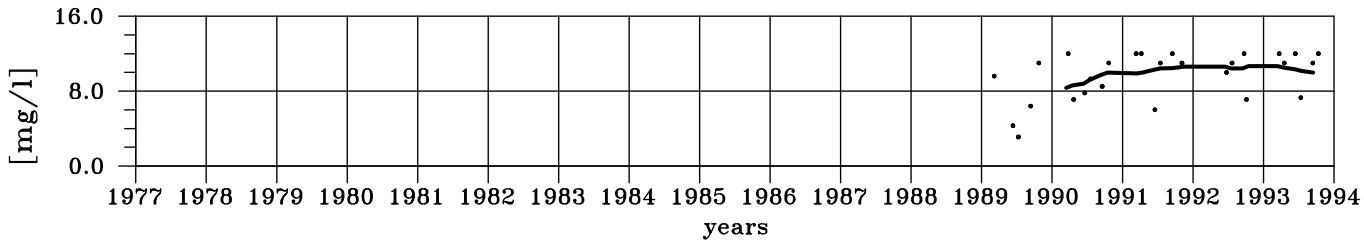



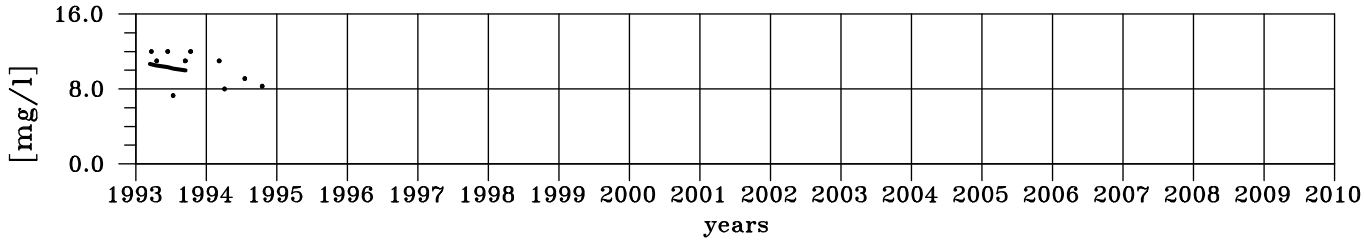
## Silicate from River Ems

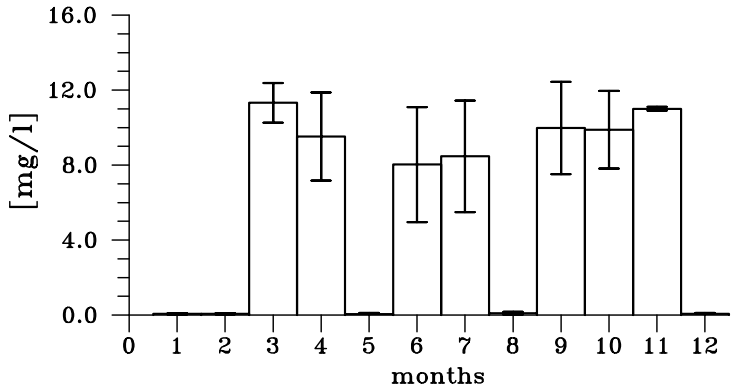
TIME SERIES
number of data: 31
mean: 9.55 mg/l
relative standard deviation: 0.26
minimum: 3.10 mg/l July 11, 1989
maximum: 12.00 mg/l March 26, 1990

LOW PASS
minimum: 8.36 mg/l March 1990
maximum: 10.66 mg/l March 1993

ANNUAL CYCLE
minimum: 0.05 mg/l May, rel. stdev: 1.02
maximum: 11.32 mg/l March, rel. stdev: 0.09



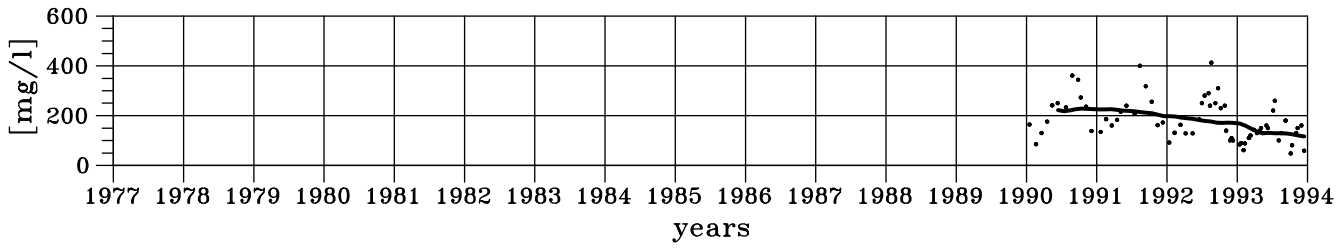



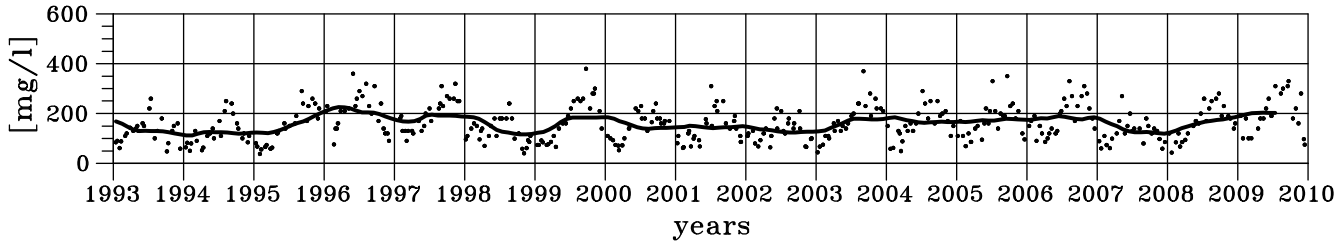
## Chloride from River Ems

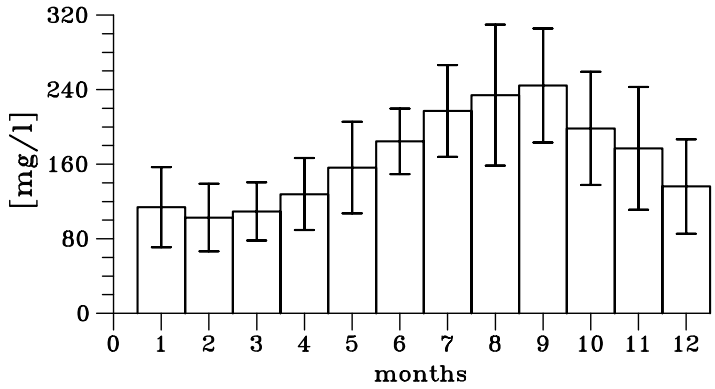
TIME SERIES
number of data: 463
mean: 164 $mg/l$
relative standard deviation: 0.44
minimum: 38 $mg/l$ February 1, 1995
maximum: 413 $mg/l$ August 19, 1992

LOW PASS
minimum: 112 $mg/l$ January 1994
maximum: 228 $mg/l$ October 1990

ANNUAL CYCLE
minimum: 103 $mg/l$ February, rel. stdev: 0.35
maximum: 244 $mg/l$ September, rel. stdev: 0.25



## 3.2 River inputs from the Dutch coast

All data of the Netherlands riverine inlets into the North Sea including the Scheldt were supplied by Rijkswaterstaat, Netherlands. From 2003 - 2009 the data were extracted from www.waterbase.nl and from 2007 on the combined concentration of nitrate and nitrite are calculated using the corresponding two different timeseries. Information on the older data is provided by the series "Jaarboek Monitoring Rijkswateren", especially edition 1998, "part 2 Kengetallen" contains statistics of discharge, concentrations and loads over the years 1989 to 1998 (pers. comm. Doekes,former RIKZ). General information on the "Jaarboek Monitoring Rijkswateren" is available on the internet under www.waterland.net.

Since the Netherlands have established a dense net of channels for regulating the waterflow and especially the waterlevel throughout the country it is usually not possible to trace back the input of a certain river, e.g. the Rhine. So in view on calculating the overall input into the North Sea we loose the information on the contribution of a single river. However, within the short description on each inlet some comments on the sources of the river will be made. Furthermore it should be mentioned that the data of the Netherlands inlets contain concentration and discharge data right at the inlet. Therefore the additional multiplication factors to get the contribution for the area downstream the gauge station are not necessary.

A certain way of handling the Netherland‘s sluice system allows to stop the flow of several inlets. This results in zero discharge values for short intervals. For these intervals the corresponding load of all substances is also zero, independent of the concentration measured during such a period. However, at the inlet Nieuwe Waterweg, the largest branch of the river Rhine, even single events of negative discharge values occur, indicating an inflow of North Sea water into the channel system. Together with the date of occurrance these values are listed in Tab. 2. For our load calculation these discharge values are set to zero.

**Tab. 2:**
*Overview on negative discharge events at the inlet Nieuwe Waterweg*

| Date | $[m^3/s]$ | Date | $[m^3/s]$ | Date | $[m^3/s]$ |
|---|---|---|---|---|---|
| 1999.11.06 | -1371 | 2003.12.21 | -1128 | 2007.01.04 | -49 |
| 1999.11.27 | -98 | 2004.01.09 | -126 | 2007.01.18 | -955 |
| 1999.12.01 | -194 | 2004.02.08 | -99 | 2007.03.18 | -152 |
| 2000.01.29 | -391 | 2004.09.21 | -408 | 2007.11.25 | -595 |
| 2000.03.03 | -7 | 2004.12.17 | -795 | 2008.03.01 | -1004 |
| 2003.04.01 | -170 | 2005.01.02 | -473 | 2008.10.05 | -35 |
| 2003.04.02 | -490 | 2005.11.15 | -296 | 2009.01.18 | -174 |
| 2003.10.07 | -480 | 2005.11.24 | -515 | 2009.01.23 | -637 |
| 2003.11.03 | -2 | 2005.12.16 | -159 | 2009.09.09 | -240 |
| 2003.11.15 | -116 | 2006.01.17 | -28 | 2009.10.16 | -198 |
| 2003.11.30 | -202 | 2006.02.08 | -387 | 2009.11.23 | -219 |
| 2003.12.13 | -439 | 2006.10.31 | -834 | | |
| 2003.12.14 | -144 | 2006.11.11 | -1259 | | |

### 3.2.1 Lake IJssel

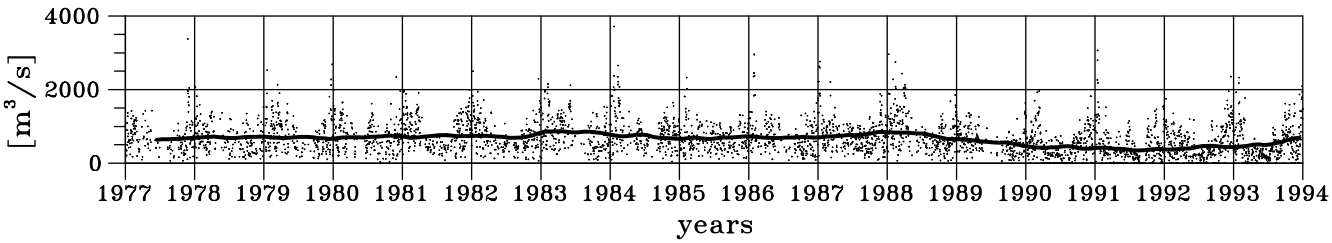
In comparison to the first report (Lenhart *et al.*, 1996), the data basis for the calculation of nutrient loads for the Lake IJssel has changed completely. While sampling at Kornwederzand and Den Oever, the two locations at the outlets of the Lake IJssel, was terminated in 1995, concentration data could be supplemented from the location Vrouwenzand. However, at this location no discharge data were available. Therefore, the combined outflow data from the locations Kornwederzand and Den Oever were used. It is presented here as "Discharge Lake IJssel" and represents the sum of two outflows from Lake IJssel. For the year 2004 nitrite concentrations were not available. Therefore for this year we used the nitrate values insted of the sum of nitrate and nitrite concentration.

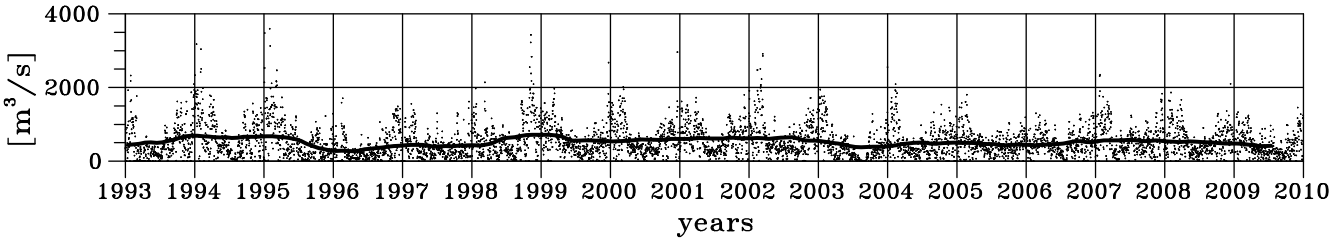
## Discharge from Lake IJssel

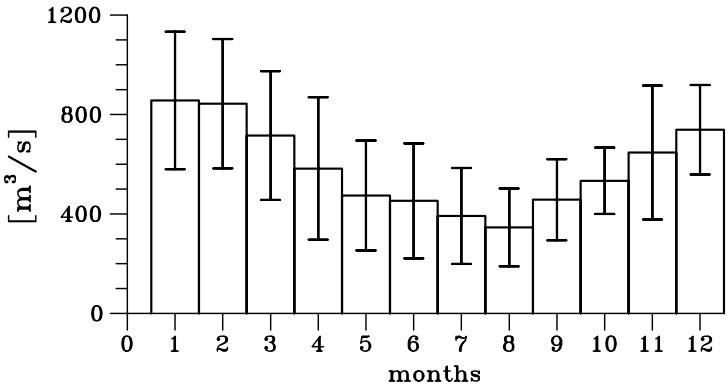
TIME SERIES
number of data: 10112
mean: 577 $m^3/s$
relative standard deviation: 0.78
minimum: 0 $m^3/s$ January 26, 1990
maximum: 3712 $m^3/s$ January 22, 1984

LOW PASS
minimum: 269 $m^3/s$ April 1996
maximum: 867 $m^3/s$ April 1983

ANNUAL CYCLE
minimum: 346 $m^3/s$ August, rel. stdev: 0.45
maximum: 857 $m^3/s$ January, rel. stdev: 0.32



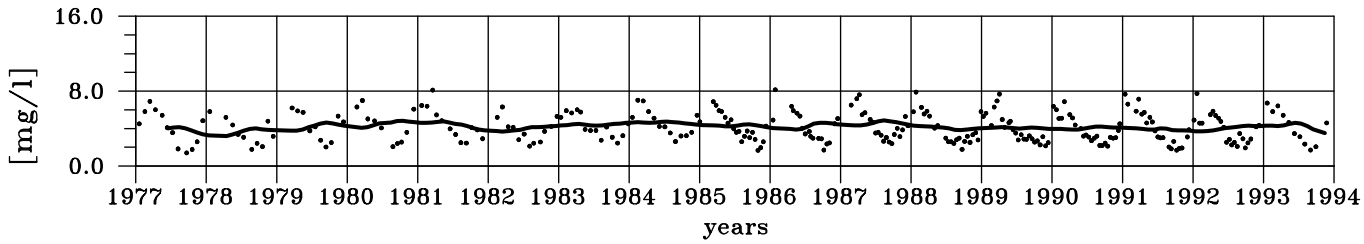



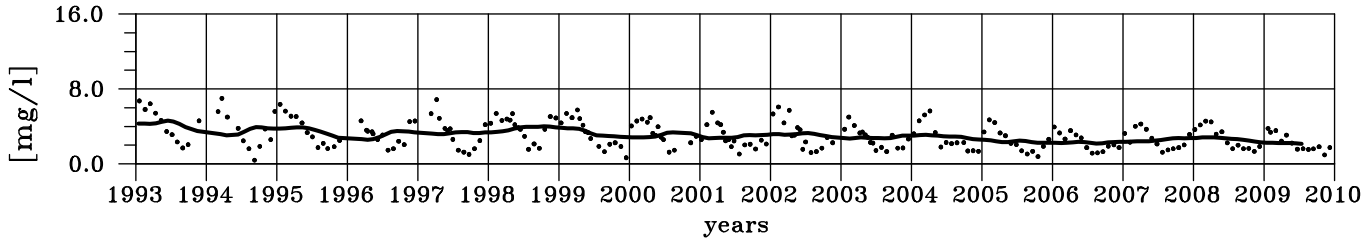
## Total Nitrogen from Lake IJssel

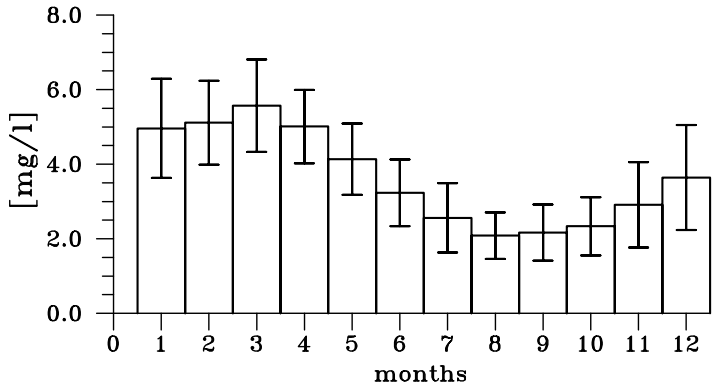
TIME SERIES
number of data: 495
mean: 3.62 mg/l
relative standard deviation: 0.43
minimum: 0.40 mg/l September 7, 1994
maximum: 8.14 mg/l January 28, 1986

LOW PASS
minimum: 2.14 mg/l July 2009
maximum: 4.85 mg/l August 1987

ANNUAL CYCLE
minimum: 2.08 mg/l August, rel. stdev: 0.30
maximum: 5.57 mg/l March, rel. stdev: 0.22



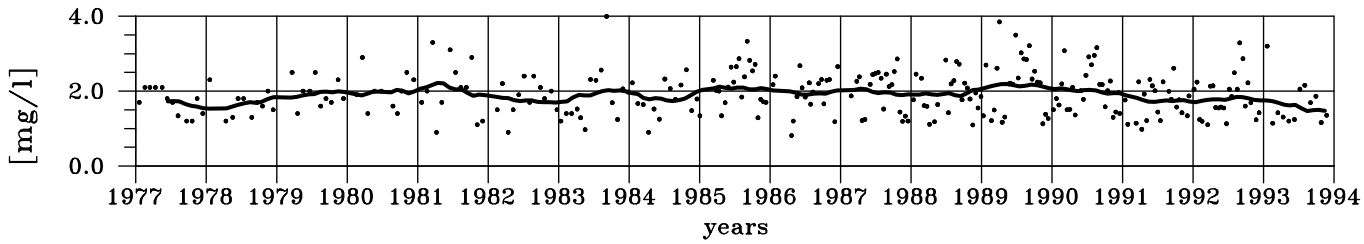



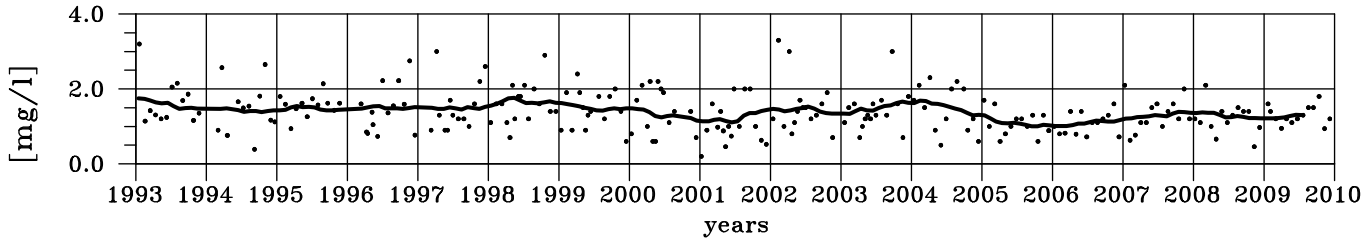
## Kjeldahl Nitrogen from Lake IJssel

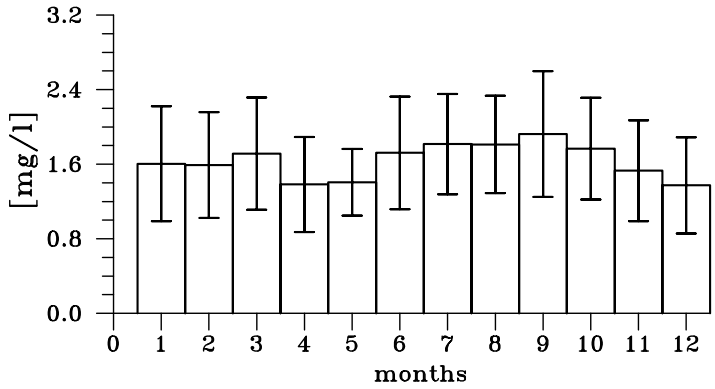
TIME SERIES
number of data: 498
mean: 1.68 mg/l
relative standard deviation: 0.37
minimum: 0.20 mg/l January 9, 2001
maximum: 3.99 mg/l September 7, 1983

LOW PASS
minimum: 1.00 mg/l September 2005
maximum: 2.22 mg/l April 1981

ANNUAL CYCLE
minimum: 1.37 mg/l December, rel. stdev: 0.38
maximum: 1.92 mg/l September, rel. stdev: 0.35



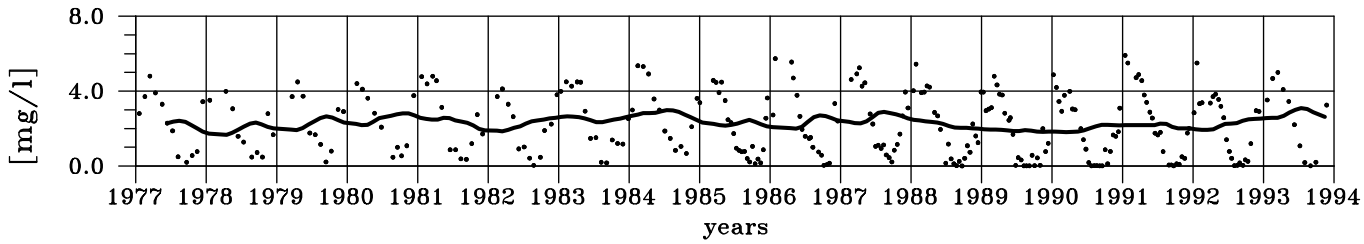



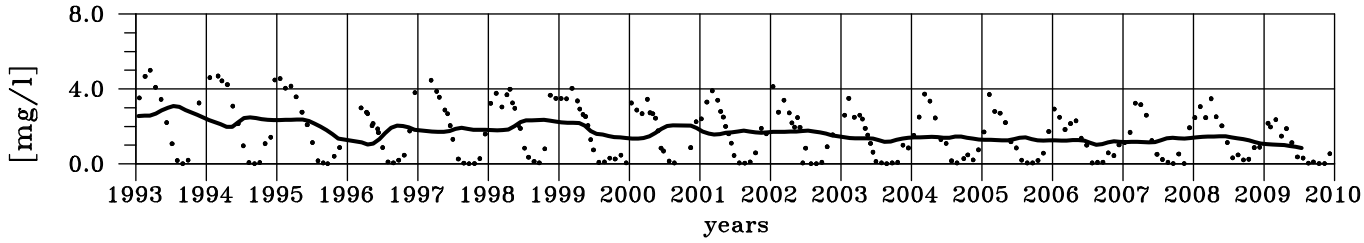
## Nitrate + Nitrite from Lake IJssel

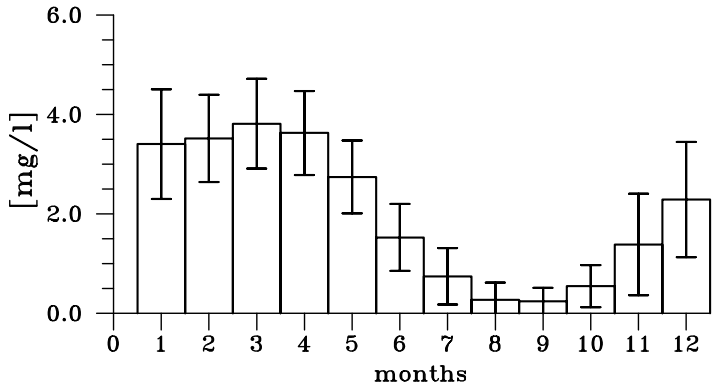
TIME SERIES
number of data: 503
mean: 1.94 mg/l
relative standard deviation: 0.79
minimum: 0.00 mg/l September 22, 1988
maximum: 5.90 mg/l January 15, 1991

LOW PASS
minimum: 0.84 mg/l July 2009
maximum: 3.09 mg/l July 1993

ANNUAL CYCLE
minimum: 0.24 mg/l September, rel. stdev: 1.11
maximum: 3.81 mg/l March, rel. stdev: 0.24



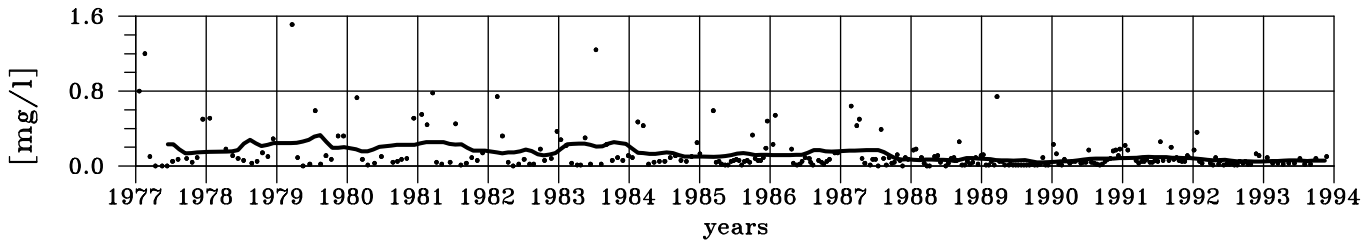



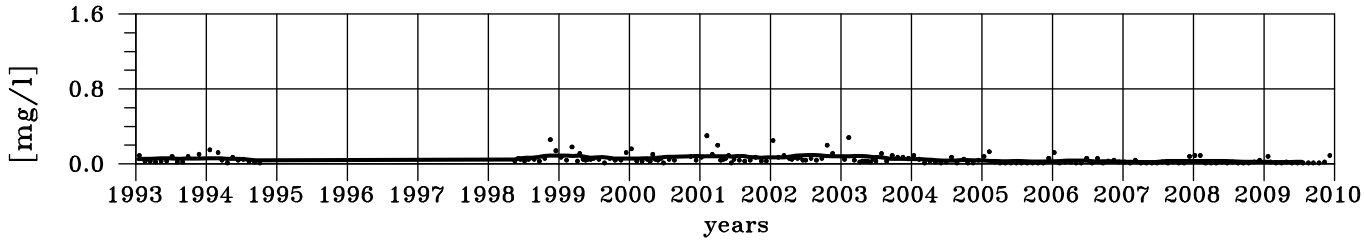
## Ammonium from Lake IJssel

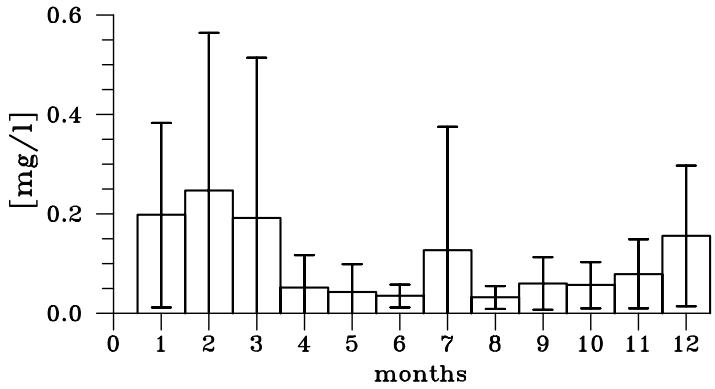
TIME SERIES
number of data: 455
mean: 0.09 mg/l
relative standard deviation: 1.71
minimum: 0.00 mg/l April 13, 1977
maximum: 1.51 mg/l March 22, 1979

LOW PASS
minimum: 0.02 mg/l May 2007
maximum: 0.33 mg/l August 1979

ANNUAL CYCLE
minimum: 0.03 mg/l August, rel. stdev: 0.73
maximum: 0.25 mg/l February, rel. stdev: 1.28



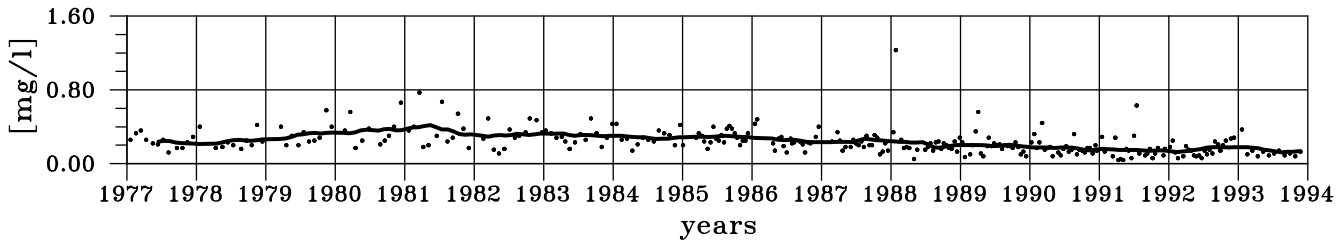



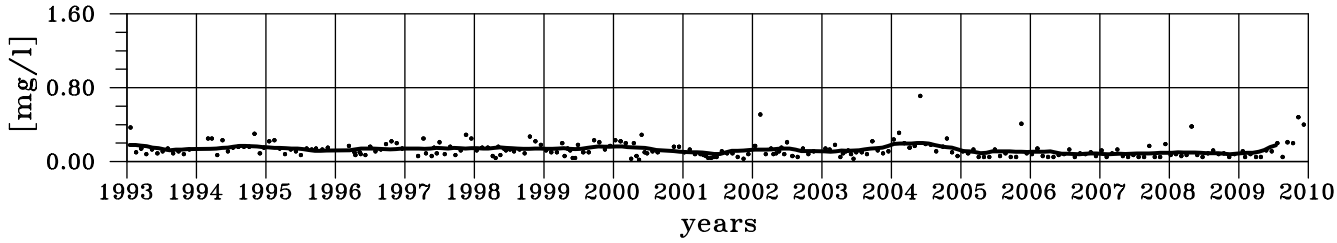
## Total Phosphorus from Lake IJssel

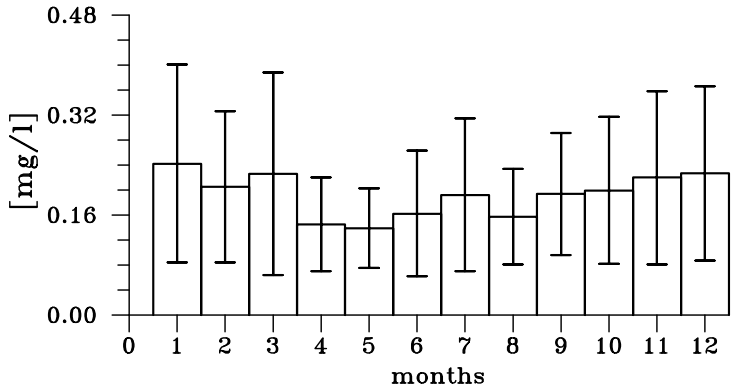
TIME SERIES
number of data: 500
mean: 0.19 mg/l
relative standard deviation: 0.67
minimum: 0.02 mg/l May 16, 2000
maximum: 1.23 mg/l January 27, 1988

LOW PASS
minimum: 0.08 mg/l November 2008
maximum: 0.42 mg/l May 1981

ANNUAL CYCLE
minimum: 0.14 mg/l May, rel. stdev: 0.46
maximum: 0.24 mg/l January, rel. stdev: 0.66



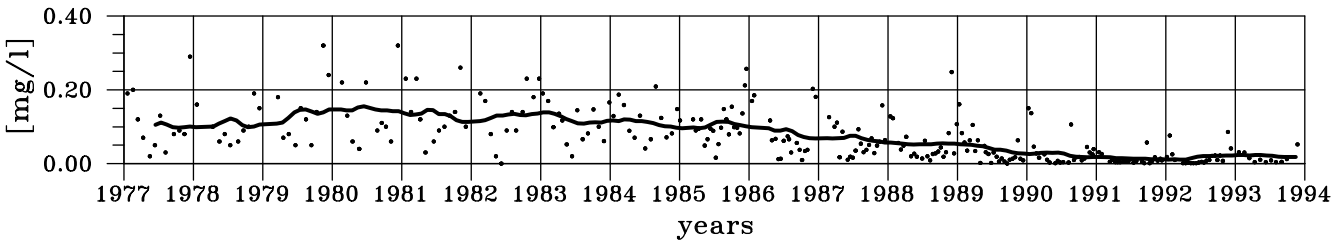



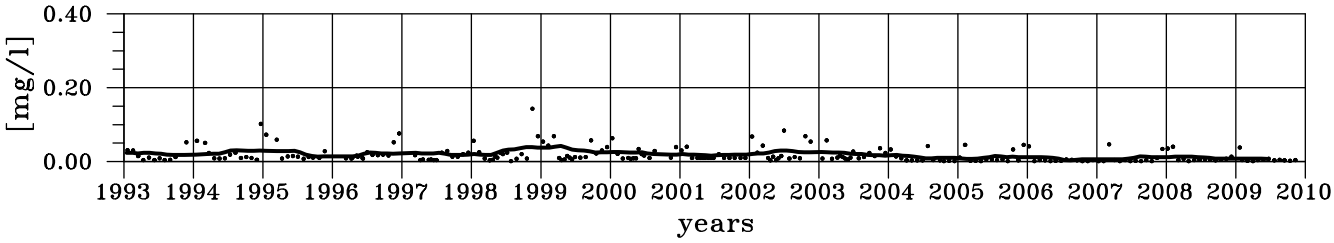
## Phosphate from Lake IJssel

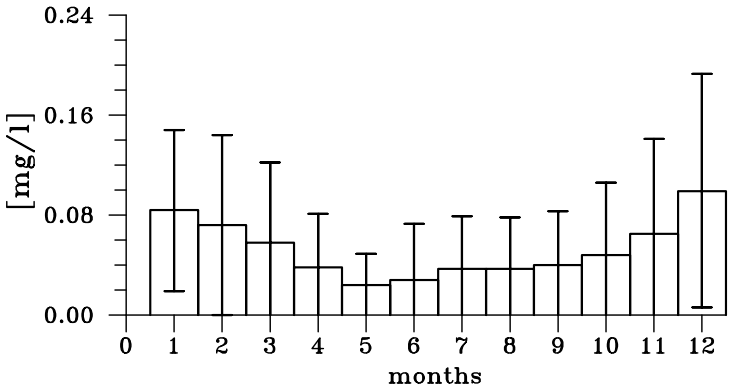
TIME SERIES
number of data: 500
mean: 0.05 mg/l
relative standard deviation: 1.23
minimum: 0.00 mg/l June 8, 1982
maximum: 0.32 mg/l November 15, 1979

LOW PASS
minimum: 0.00 mg/l August 2006
maximum: 0.16 mg/l June 1980

ANNUAL CYCLE
minimum: 0.02 mg/l May, rel. stdev: 1.06
maximum: 0.10 mg/l December, rel. stdev: 0.94



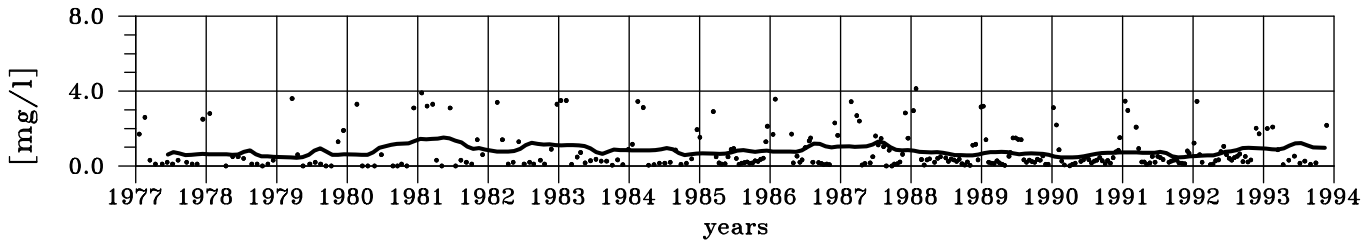



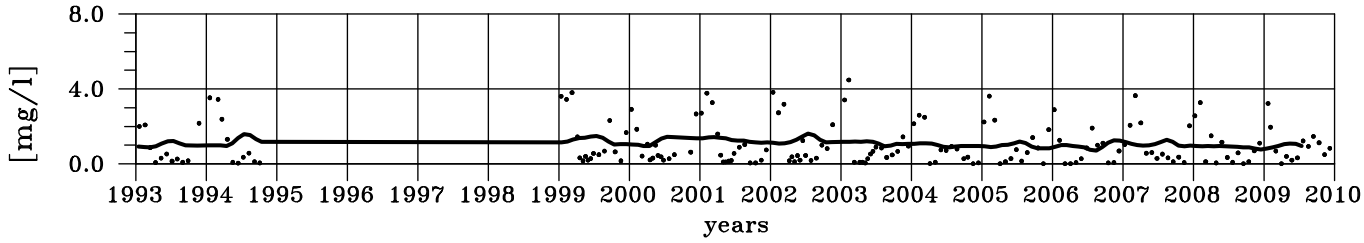
## Silicate from Lake IJssel

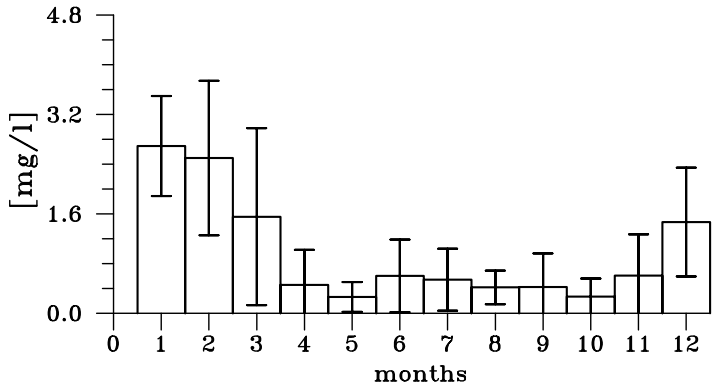
TIME SERIES
number of data: 445
mean: 0.86 mg/l
relative standard deviation: 1.20
minimum: 0.00 mg/l April 13, 1978
maximum: 4.48 mg/l February 10, 2003

LOW PASS
minimum: 0.43 mg/l April 1979
maximum: 1.60 mg/l July 2002

ANNUAL CYCLE
minimum: 0.26 mg/l May, rel. stdev: 0.92
maximum: 2.69 mg/l January, rel. stdev: 0.30



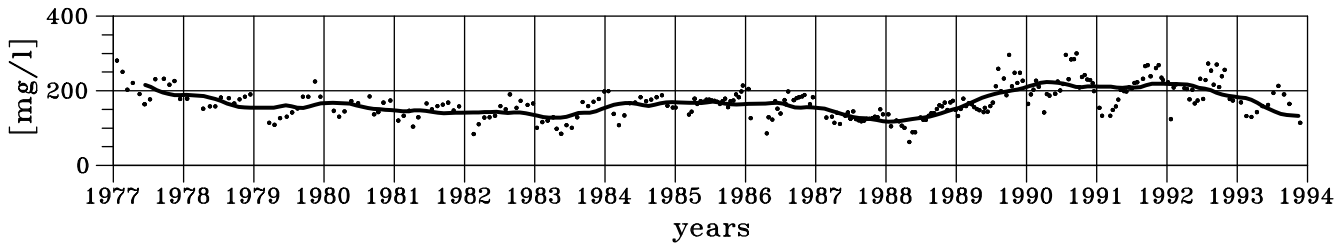



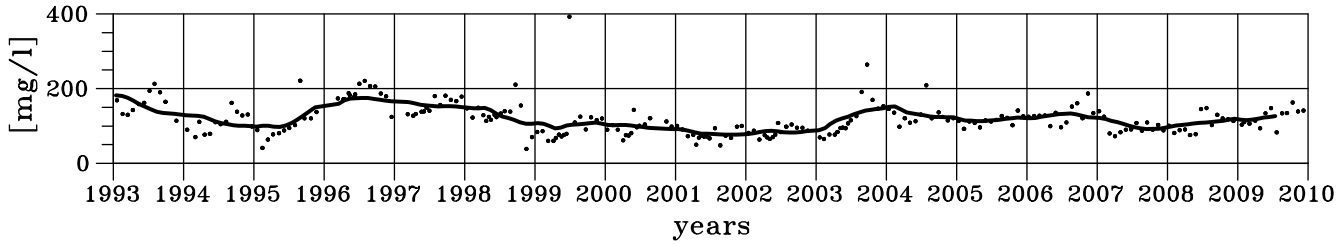
## Chloride from Lake IJssel

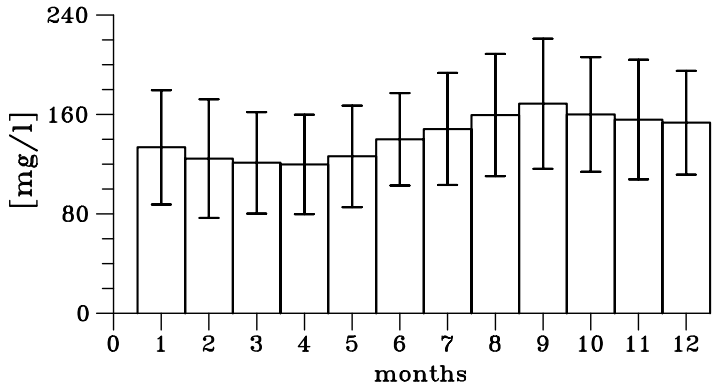
TIME SERIES
number of data: 502
mean: 147 $mg/l$
relative standard deviation: 0.35
minimum: 39 $mg/l$ November 17, 1998
maximum: 393 $mg/l$ June 29, 1999

LOW PASS
minimum: 77 $mg/l$ October 2001
maximum: 223 $mg/l$ April 1990

ANNUAL CYCLE
minimum: 120 $mg/l$ April, rel. stdev: 0.33
maximum: 169 $mg/l$ September, rel. stdev: 0.31



### 3.2.2 Nordzeekanaal

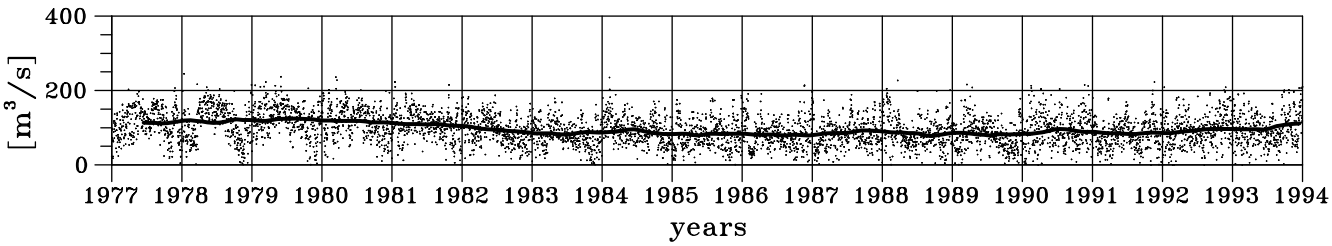
This channel represents the direct connection from Amsterdam to the North Sea. Additional water masses enter from the Markermeer which is separated from the Lake IJssel by a damm. Daily discharge data and biweekly samples for all the concentration values were available. The sampling took place about 2 km before the sluice system. The elevated chloride content of about 2000 $mg/l$ was caused by opening the locks for in- and outgoing ships, thereby permitting seawater to enter the sluice system. For the year 2004 nitrite concentrations were not available. Therefore for this year we used the nitrate values insted of the sum of nitrate and nitrite concentration.

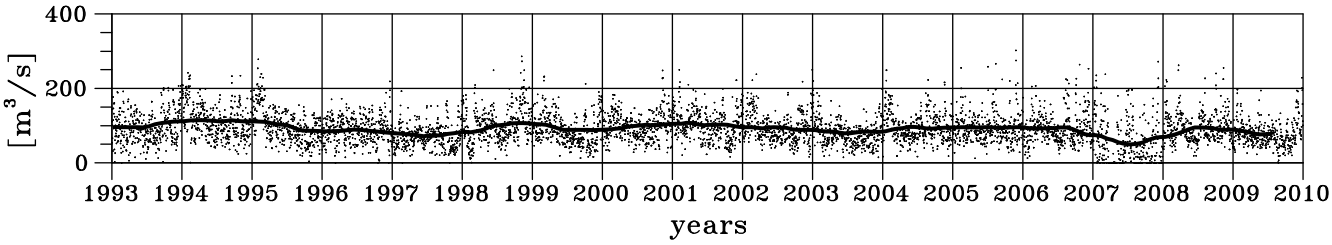
## Discharge from Nordzeekanaal

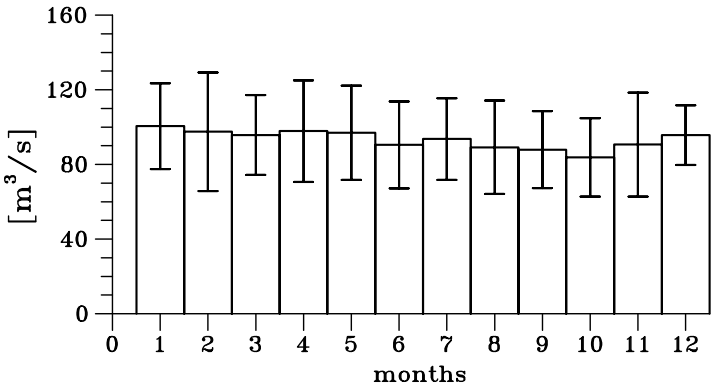
TIME SERIES
number of data: 12031
mean: 93 $m^3/s$
relative standard deviation: 0.45
minimum: 0 $m^3/s$ March 24, 1990
maximum: 302 $m^3/s$ November 26, 2005

LOW PASS
minimum: 50 $m^3/s$ July 2007
maximum: 124 $m^3/s$ August 1979

ANNUAL CYCLE
minimum: 84 $m^3/s$ October, rel. stdev: 0.25
maximum: 100 $m^3/s$ January, rel. stdev: 0.23



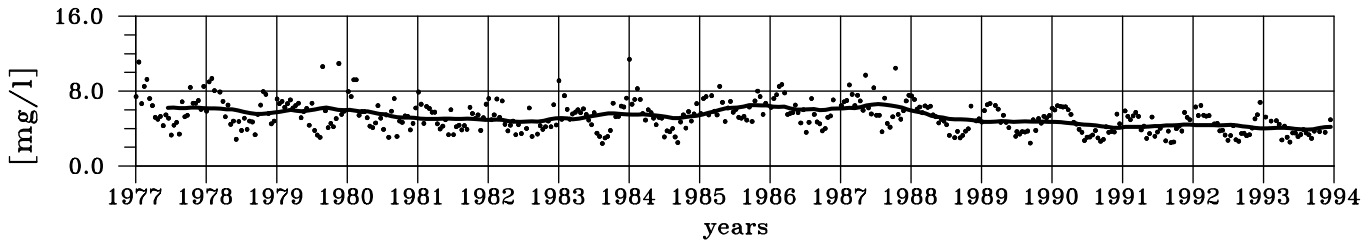



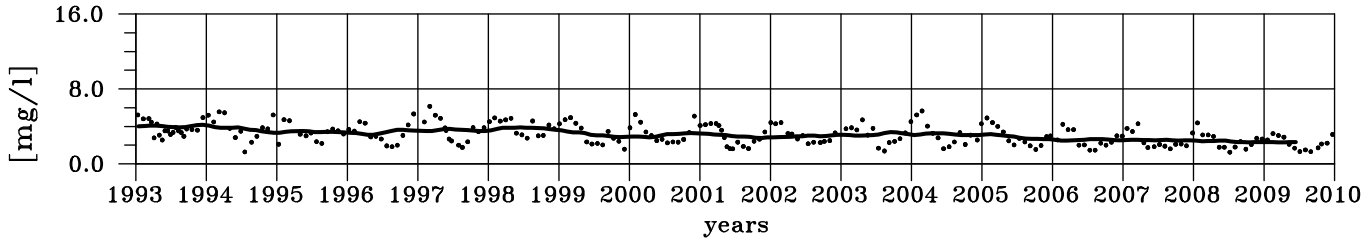
## Total Nitrogen from Nordzeekanaal

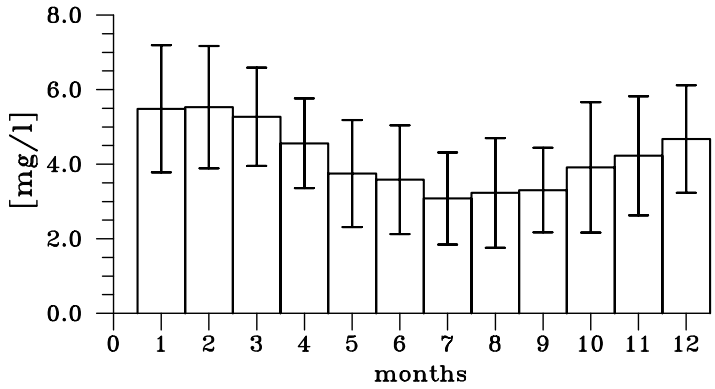
TIME SERIES
number of data: 633
mean: 4.55 mg/l
relative standard deviation: 0.39
minimum: 1.23 mg/l July 7, 2008
maximum: 11.40 mg/l January 2, 1984

LOW PASS
minimum: 2.30 mg/l March 2009
maximum: 6.61 mg/l July 1987

ANNUAL CYCLE
minimum: 3.08 mg/l July, rel. stdev: 0.40
maximum: 5.53 mg/l February, rel. stdev: 0.30



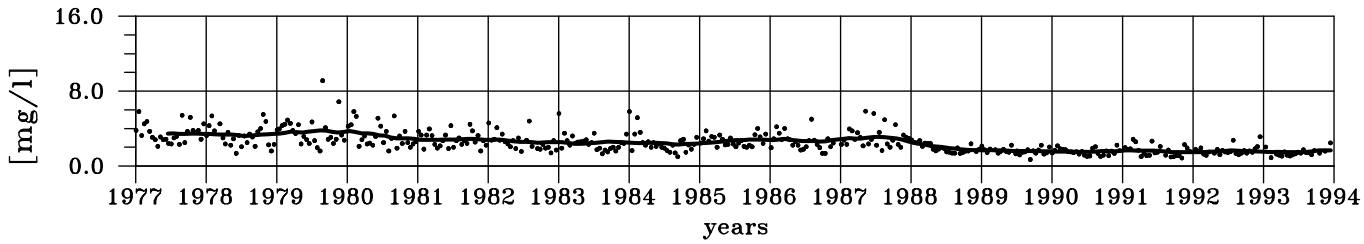



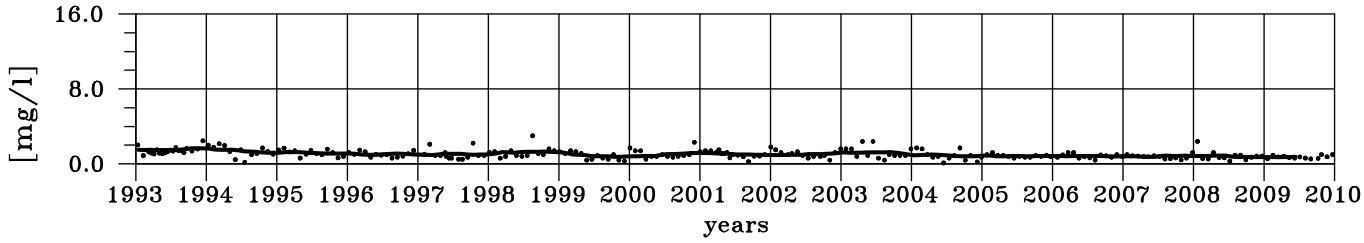
## Kjeldahl Nitrogen from Nordzeekanaal

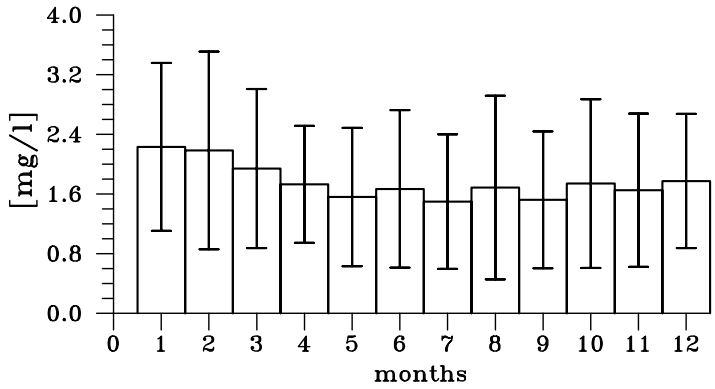
TIME SERIES
number of data: 637
mean: 2.00 mg/l
relative standard deviation: 0.60
minimum: 0.10 mg/l June 16, 2004
maximum: 9.10 mg/l August 27, 1979

LOW PASS
minimum: 0.72 mg/l December 2008
maximum: 3.79 mg/l August 1979

ANNUAL CYCLE
minimum: 1.50 mg/l July, rel. stdev: 0.60
maximum: 2.23 mg/l January, rel. stdev: 0.50



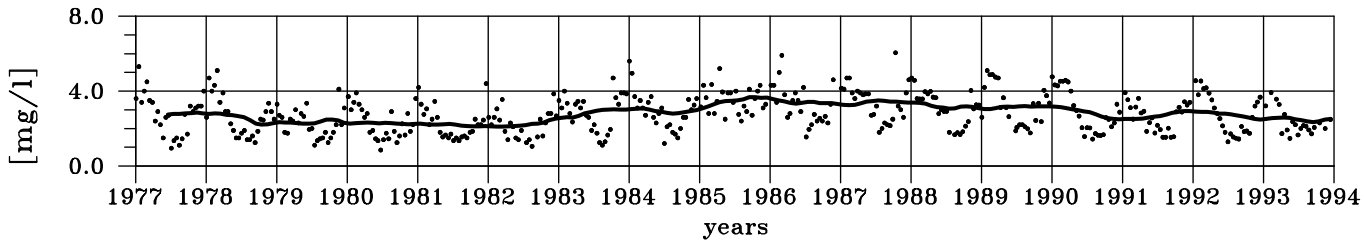



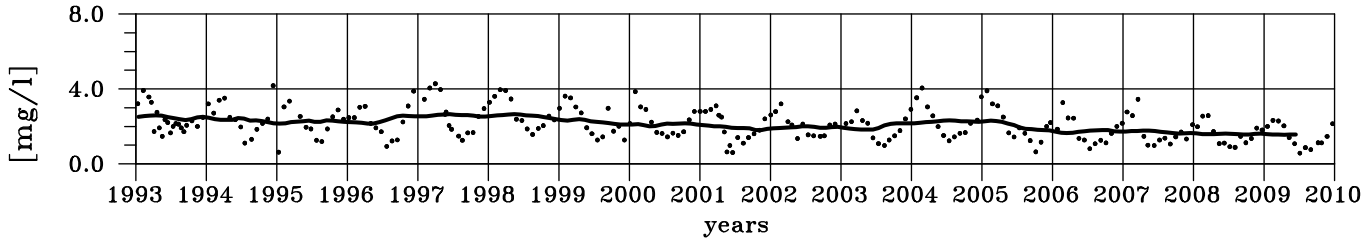
## Nitrate + Nitrite from Nordzeekanaal

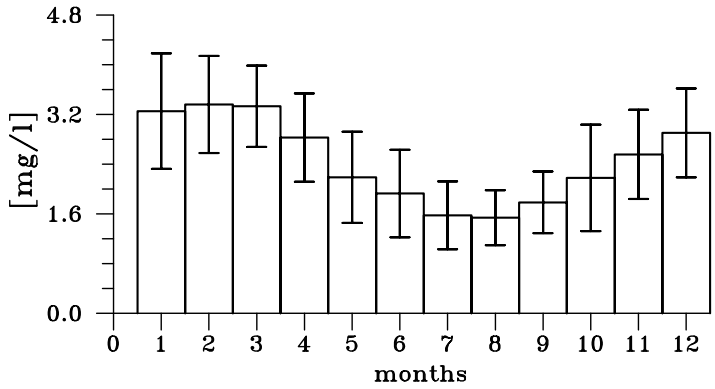
TIME SERIES
number of data: 638
mean: 2.56 mg/l
relative standard deviation: 0.40
minimum: 0.58 mg/l July 6, 2009
maximum: 6.05 mg/l October 12, 1987

LOW PASS
minimum: 1.56 mg/l April 2009
maximum: 3.67 mg/l October 1985

ANNUAL CYCLE
minimum: 1.54 mg/l August, rel. stdev: 0.29
maximum: 3.36 mg/l February, rel. stdev: 0.23



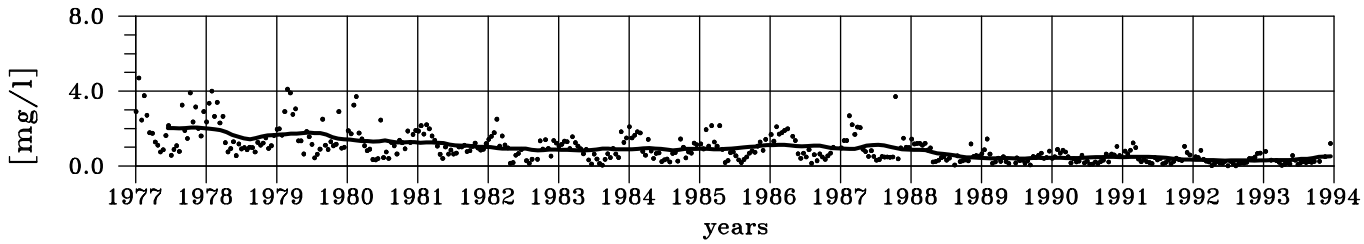



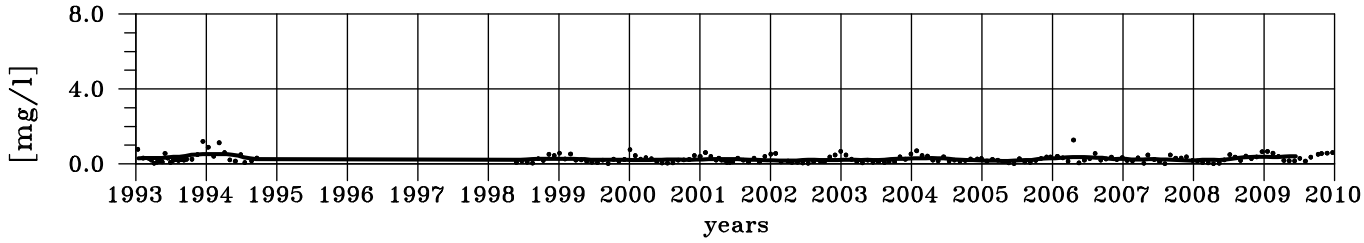
## Ammonium from Nordzeekanaal

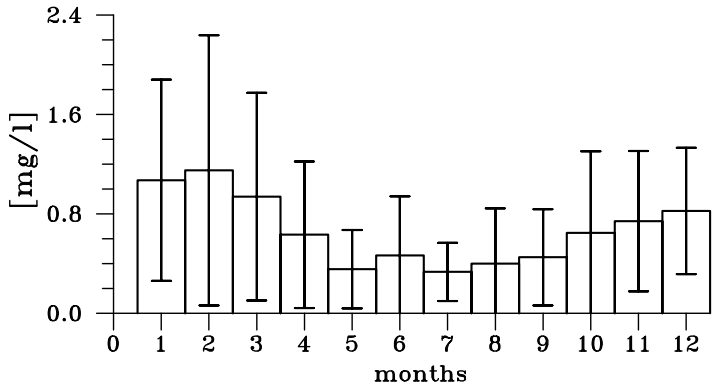
TIME SERIES
number of data: 591
mean: 0.77 mg/l
relative standard deviation: 0.98
minimum: 0.01 mg/l June 30, 1992
maximum: 4.70 mg/l January 17, 1977

LOW PASS
minimum: 0.16 mg/l April 2005
maximum: 2.05 mg/l November 1977

ANNUAL CYCLE
minimum: 0.33 mg/l July, rel. stdev: 0.71
maximum: 1.15 mg/l February, rel. stdev: 0.95



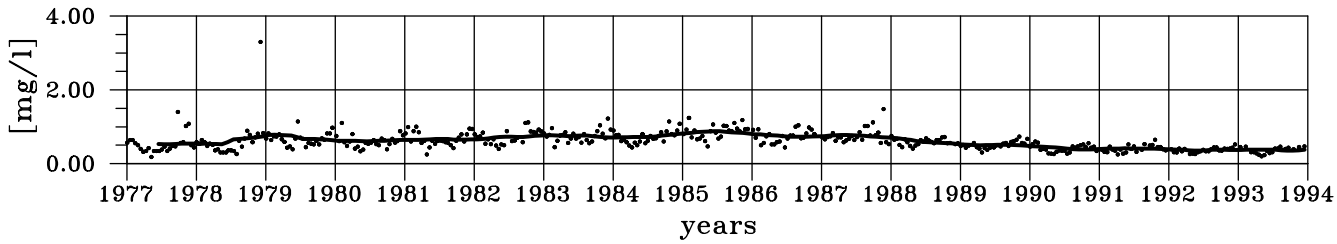



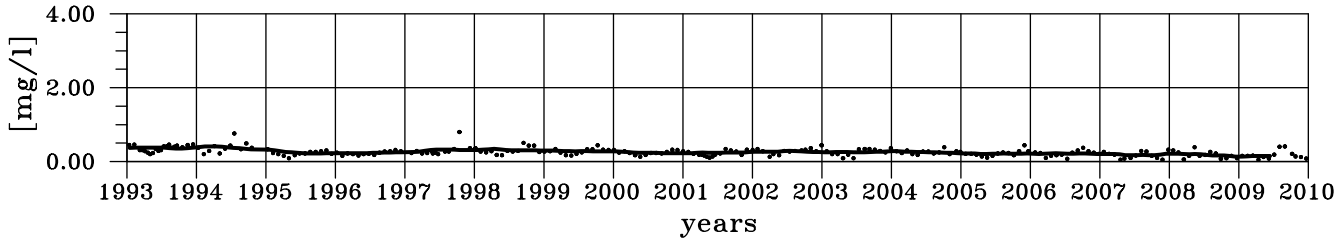
## Total Phosphorus from Nordzeekanaal

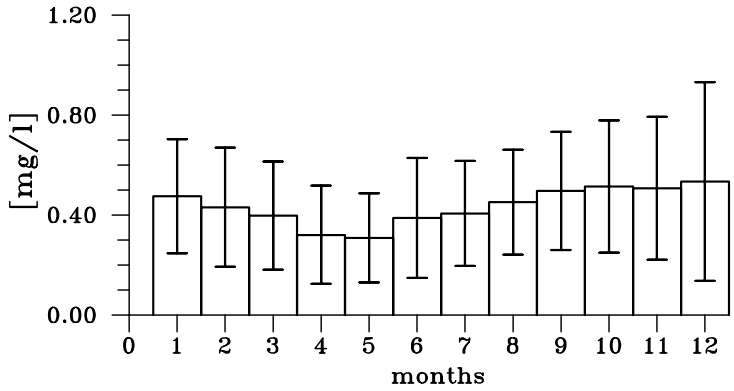
TIME SERIES
number of data: 634
mean: 0.49 mg/l
relative standard deviation: 0.56
minimum: 0.05 mg/l April 19, 2007
maximum: 3.30 mg/l December 4, 1978

LOW PASS
minimum: 0.14 mg/l January 2009
maximum: 0.88 mg/l June 1985

ANNUAL CYCLE
minimum: 0.31 mg/l May, rel. stdev: 0.58
maximum: 0.53 mg/l December, rel. stdev: 0.74



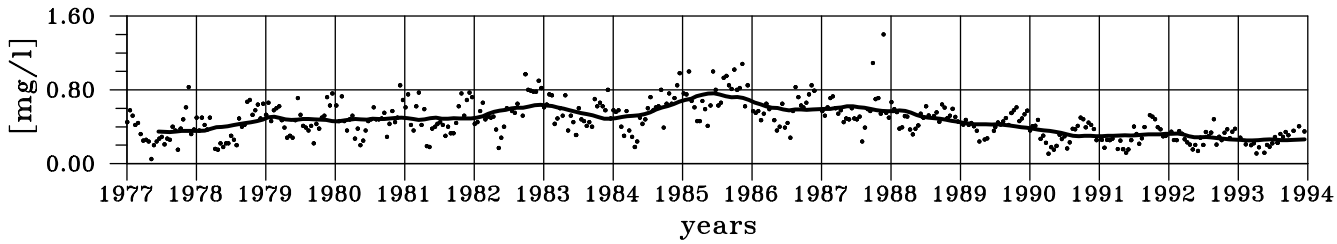



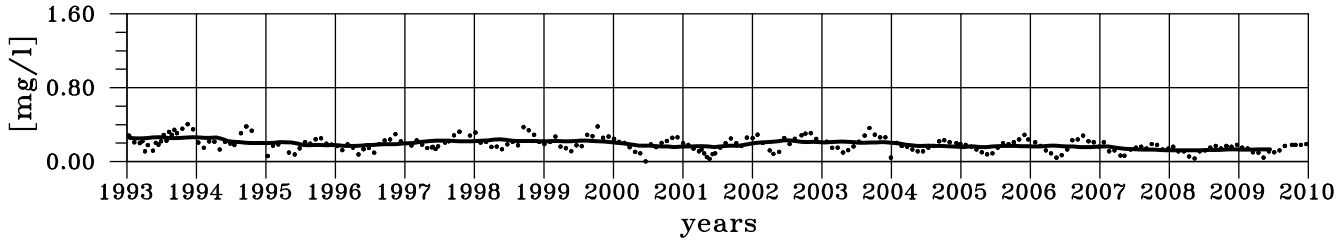
## Phosphate from Nordzeekanaal

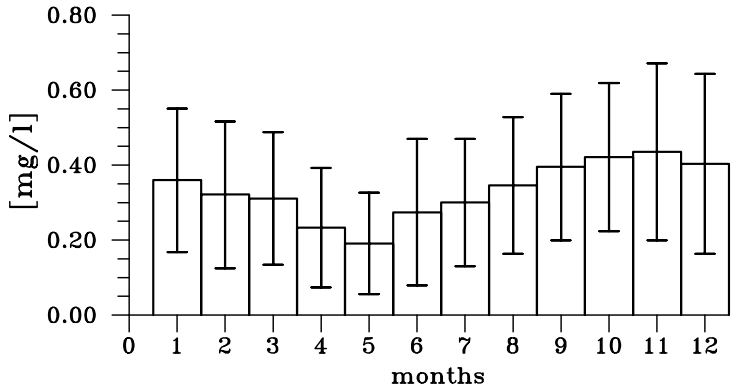
TIME SERIES
number of data: 628
mean: 0.37 mg/l
relative standard deviation: 0.58
minimum: 0.00 mg/l June 19, 2000
maximum: 1.40 mg/l November 23, 1987

LOW PASS
minimum: 0.12 mg/l February 2008
maximum: 0.76 mg/l June 1985

ANNUAL CYCLE
minimum: 0.19 mg/l May, rel. stdev: 0.71
maximum: 0.43 mg/l November, rel. stdev: 0.54



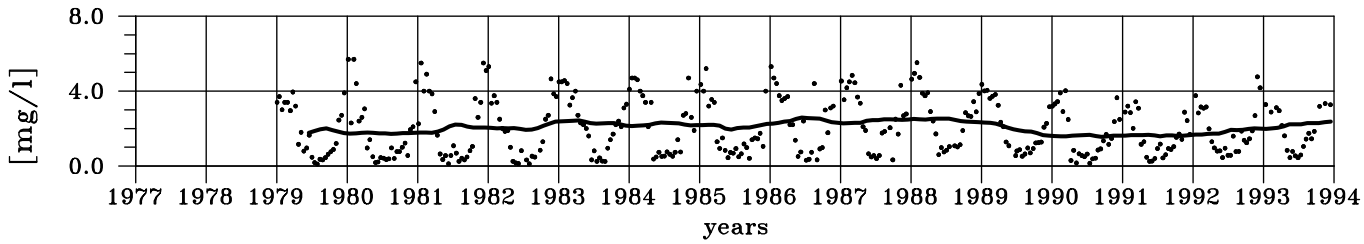



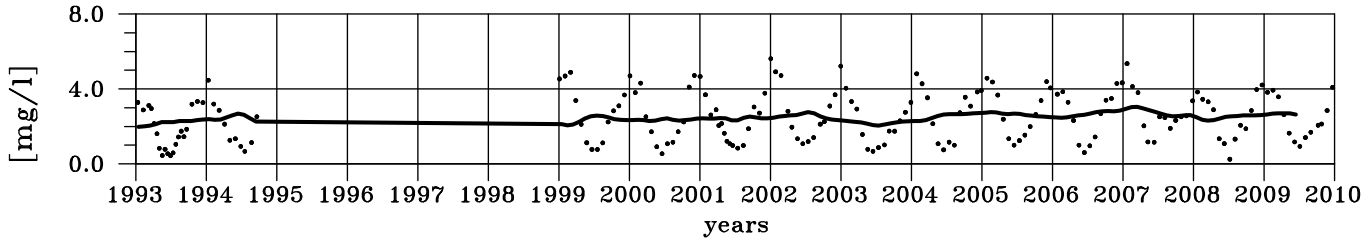
## Silicate from Nordzeekanaal

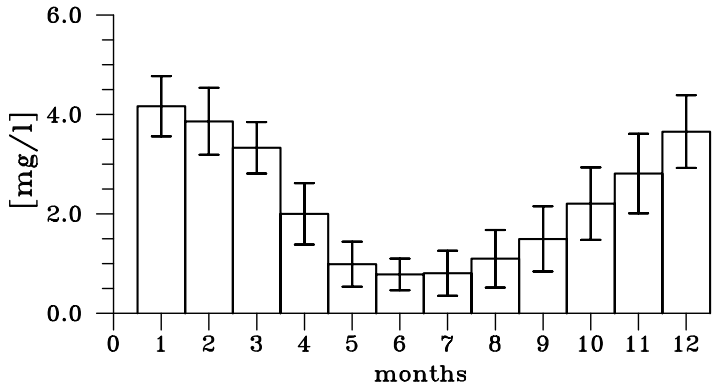
TIME SERIES
number of data: 530
mean: 2.20 mg/l
relative standard deviation: 0.65
minimum: 0.10 mg/l July 30, 1979
maximum: 5.70 mg/l January 7, 1980

LOW PASS
minimum: 1.56 mg/l September 1990
maximum: 3.04 mg/l March 2007

ANNUAL CYCLE
minimum: 0.78 mg/l June, rel. stdev: 0.40
maximum: 4.17 mg/l January, rel. stdev: 0.15



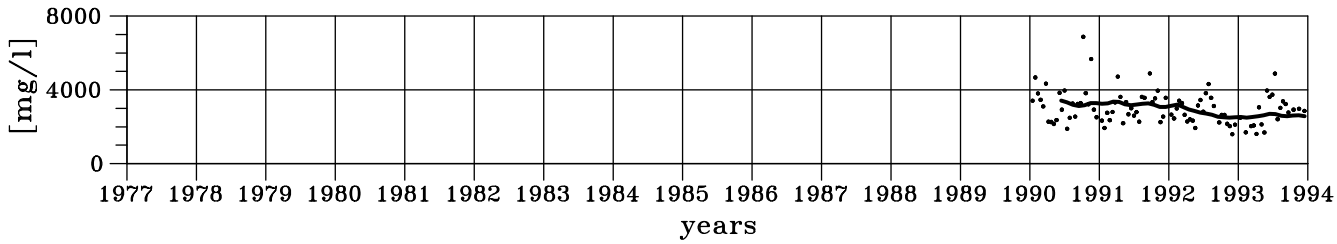



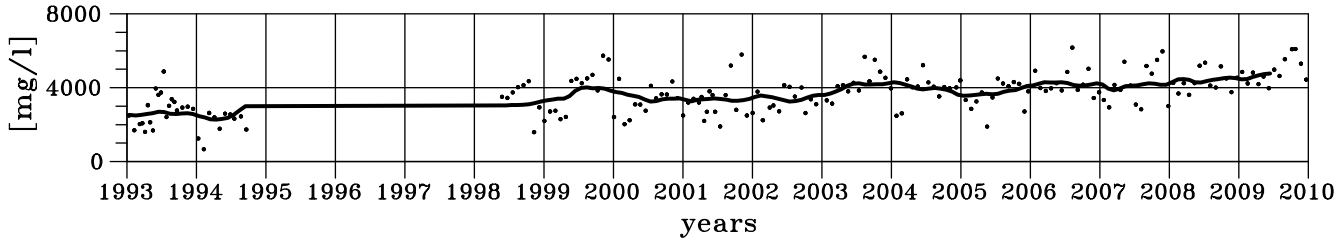
## Chloride from Nordzeekanaal

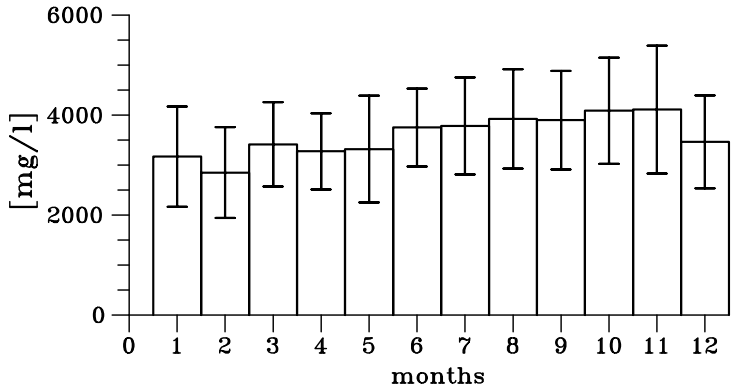
TIME SERIES
number of data: 257
mean: 3501 $mg/l$
relative standard deviation: 0.30
minimum: 663 $mg/l$ February 8, 1994
maximum: 6870 $mg/l$ October 8, 1990

LOW PASS
minimum: 2269 $mg/l$ April 1994
maximum: 4770 $mg/l$ June 2009

ANNUAL CYCLE
minimum: 2848 $mg/l$ February, rel. stdev: 0.32
maximum: 4111 $mg/l$ November, rel. stdev: 0.31



### 3.2.3 Nieuwe Waterweg

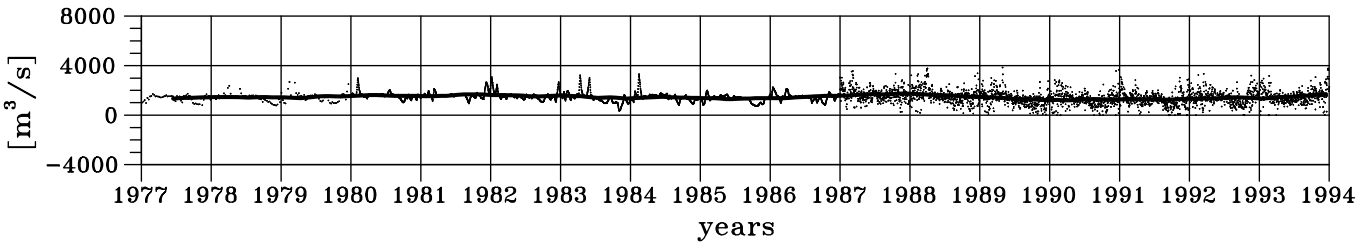
The sampling station lies just beyond the combined outflow from Nieuwe Maas and Oude Maas. Both waterways have different connections to the Waal, the largest branche of the river Rhine. For the calculation of discharge weekly measured data until 1980 and daily data since 1980 are available. Since 1987 these data were modelled instead of measured. The model simulates the discharge using the information of the phase of the tide, water surface elevation as well as the movement of the sluices. The change from measured discharge towards modelled discharge can clearly be seen in the figure of the time series. All concentrations were measured every two weeks. The sampling location was situated in the mixing zone, near the city of Maassluis which results, on a tidal average basis, in 10 to 15 % seawater. The 24-hour, and therefore tidal-averaged, mean chloride content is about 700 $mg/l$. For the year 2004 nitrite concentrations were not available. Therefore for this year we used the nitrate values insted of the sum of nitrate and nitrite concentration.

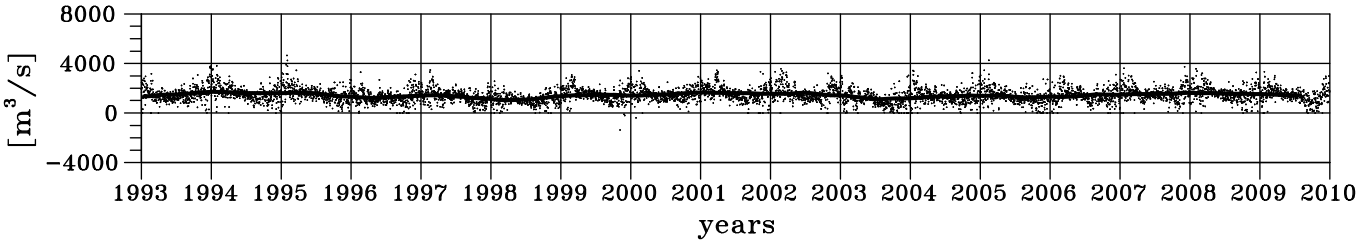
## Discharge from Nieuwe Waterweg

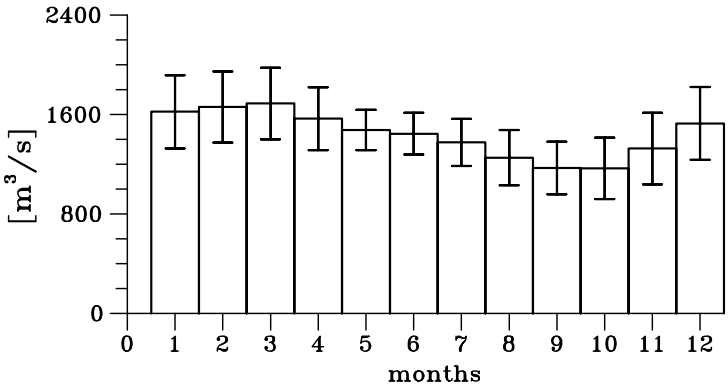
TIME SERIES
number of data: 11102
mean: 1441 $m^3/s$
relative standard deviation: 0.37
minimum: -1371 $m^3/s$ November 6, 1999
maximum: 4649 $m^3/s$ January 31, 1995

LOW PASS
minimum: 1037 $m^3/s$ April 1998
maximum: 1740 $m^3/s$ November 1987

ANNUAL CYCLE
minimum: 1167 $m^3/s$ October, rel. stdev: 0.21
maximum: 1688 $m^3/s$ March, rel. stdev: 0.17



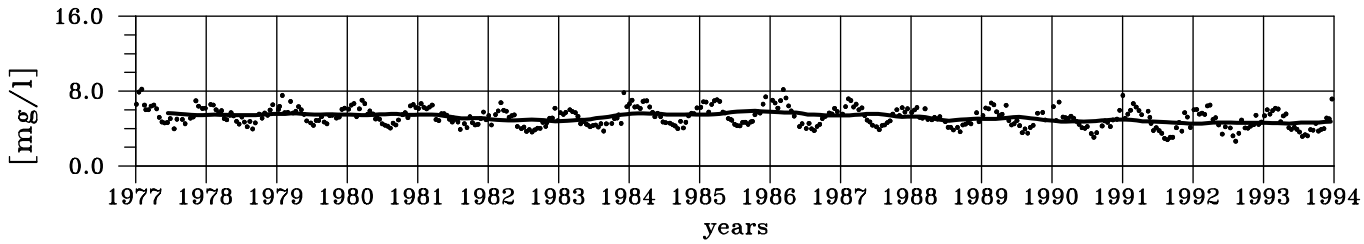



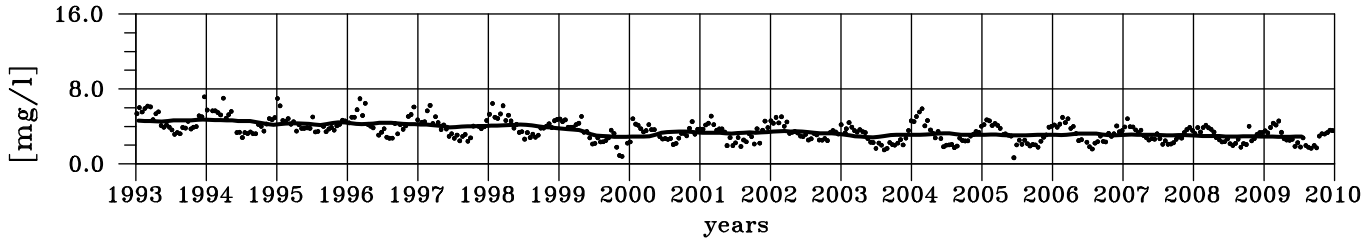
## Total Nitrogen from Nieuwe Waterweg

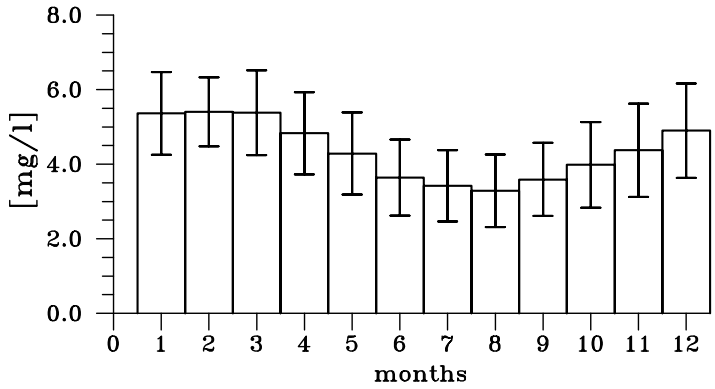
TIME SERIES
number of data: 826
mean: 4.34 mg/l
relative standard deviation: 0.31
minimum: 0.65 mg/l June 15, 2005
maximum: 8.20 mg/l February 1, 1977

LOW PASS
minimum: 2.82 mg/l June 2003
maximum: 5.88 mg/l October 1985

ANNUAL CYCLE
minimum: 3.29 mg/l August, rel. stdev: 0.30
maximum: 5.40 mg/l February, rel. stdev: 0.17



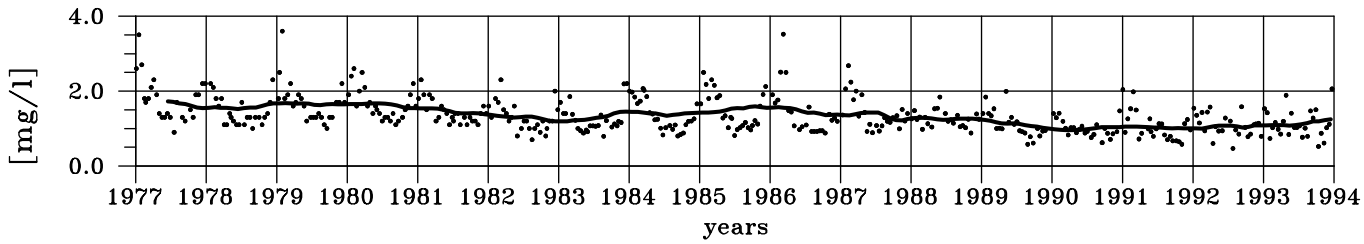



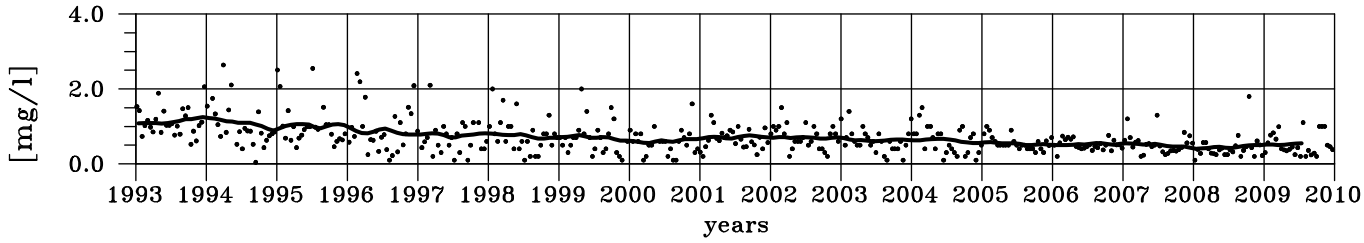
## Kjeldahl Nitrogen from Nieuwe Waterweg

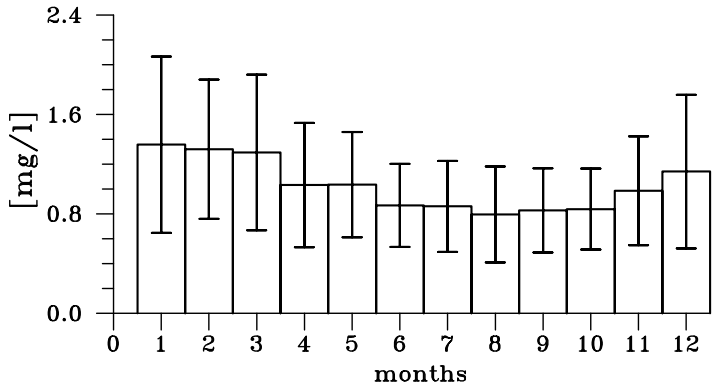
TIME SERIES
number of data: 829
mean: 1.02 mg/l
relative standard deviation: 0.55
minimum: 0.04 mg/l September 14, 1994
maximum: 3.60 mg/l January 30, 1979

LOW PASS
minimum: 0.40 mg/l January 2008
maximum: 1.73 mg/l June 1977

ANNUAL CYCLE
minimum: 0.80 mg/l August, rel. stdev: 0.49
maximum: 1.36 mg/l January, rel. stdev: 0.52



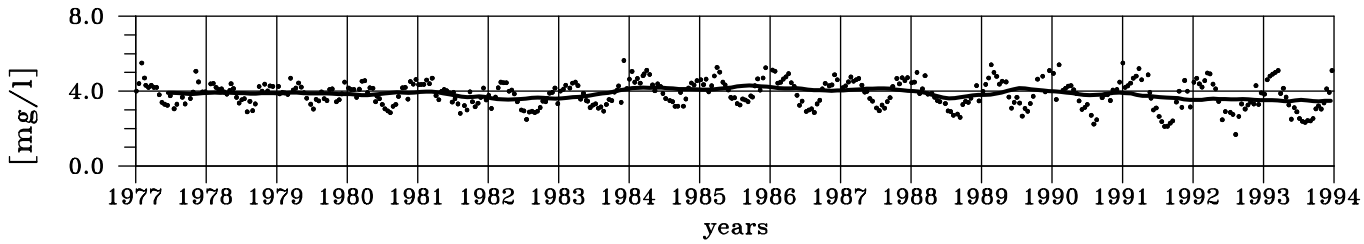



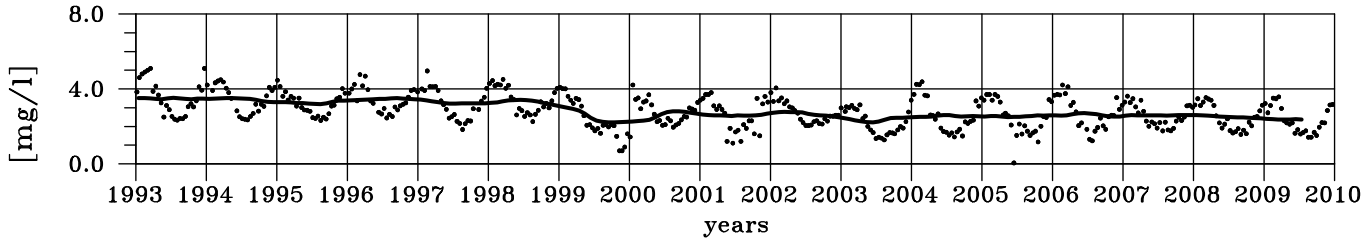
## Nitrate + Nitrite from Nieuwe Waterweg

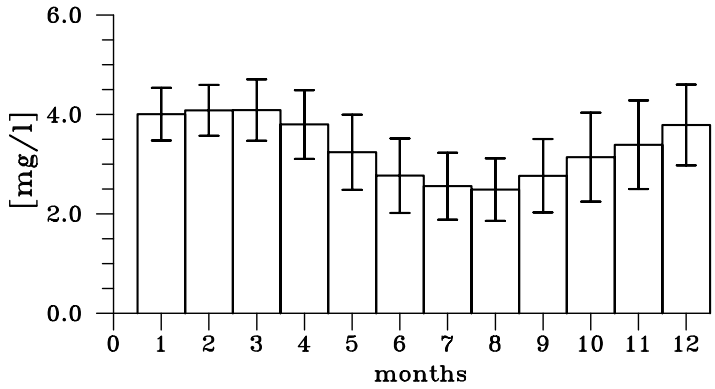
TIME SERIES
number of data: 832
mean: 3.32 mg/l
relative standard deviation: 0.28
minimum: 0.05 mg/l June 15, 2005
maximum: 5.63 mg/l December 5, 1983

LOW PASS
minimum: 2.21 mg/l June 2003
maximum: 4.30 mg/l September 1985

ANNUAL CYCLE
minimum: 2.49 mg/l August, rel. stdev: 0.25
maximum: 4.09 mg/l March, rel. stdev: 0.15



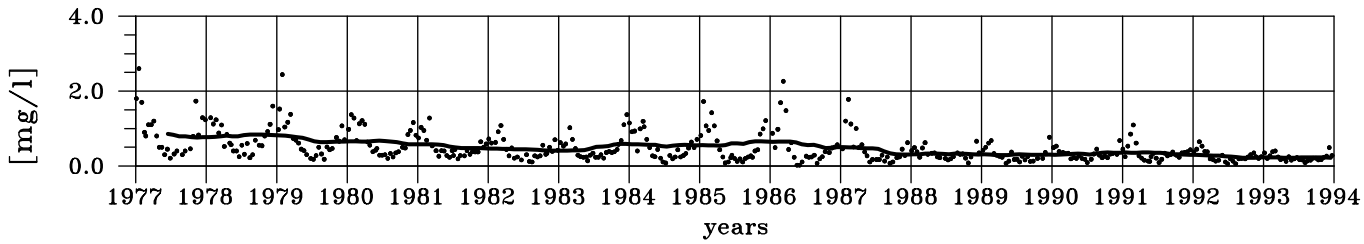



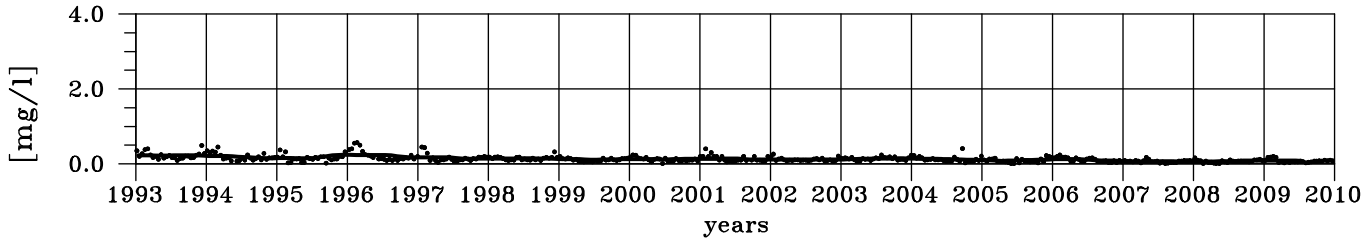
## Ammonium from Nieuwe Waterweg

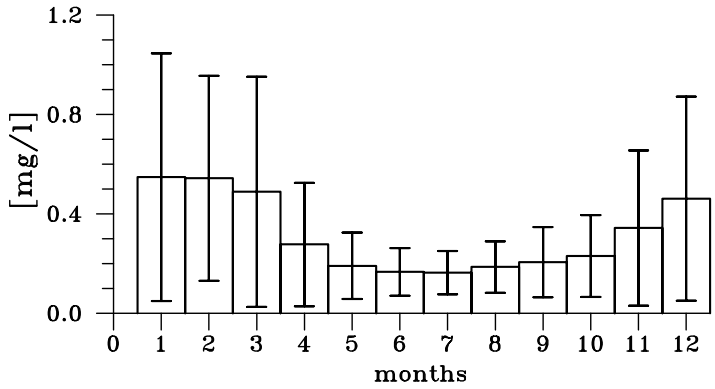
TIME SERIES
number of data: 837
mean: 0.31 mg/l
relative standard deviation: 1.08
minimum: 0.01 mg/l June 21, 2000
maximum: 2.60 mg/l January 18, 1977

LOW PASS
minimum: 0.06 mg/l December 2007
maximum: 0.85 mg/l June 1977

ANNUAL CYCLE
minimum: 0.16 mg/l July, rel. stdev: 0.53
maximum: 0.55 mg/l January, rel. stdev: 0.91



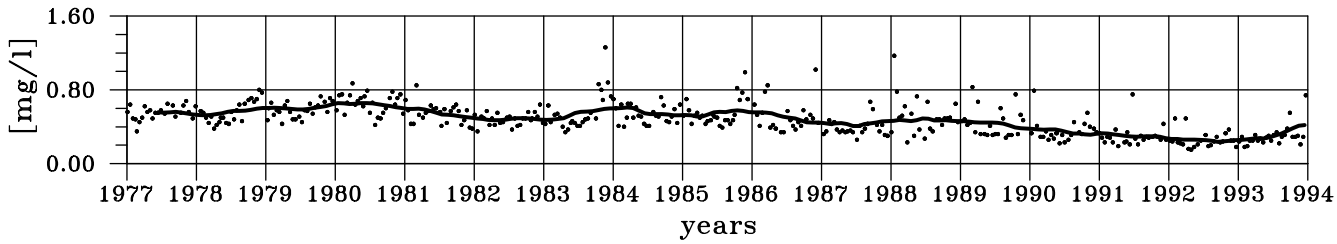



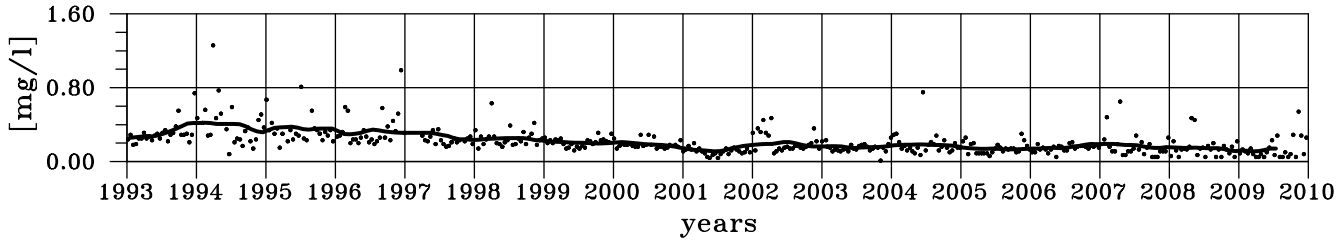
## Total Phosphorus from Nieuwe Waterweg

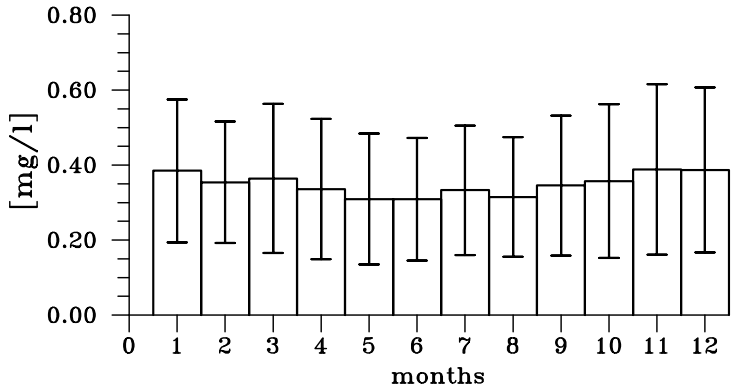
TIME SERIES
number of data: 825
mean: 0.34 mg/l
relative standard deviation: 0.59
minimum: 0.01 mg/l November 5, 2003
maximum: 1.26 mg/l November 21, 1983

LOW PASS
minimum: 0.11 mg/l June 2001
maximum: 0.65 mg/l January 1980

ANNUAL CYCLE
minimum: 0.31 mg/l June, rel. stdev: 0.53
maximum: 0.39 mg/l November, rel. stdev: 0.59



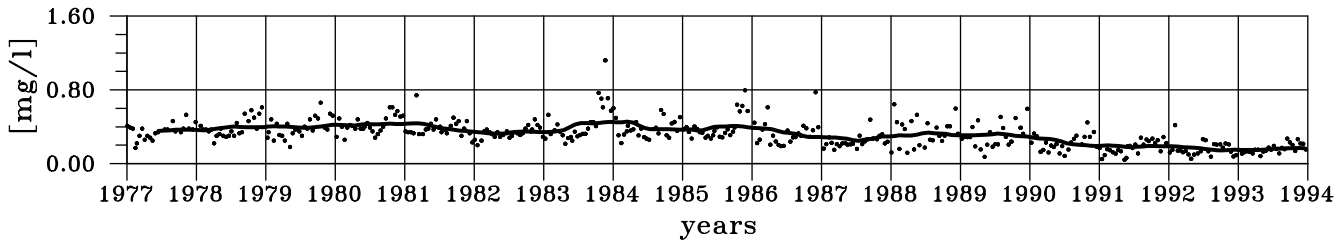



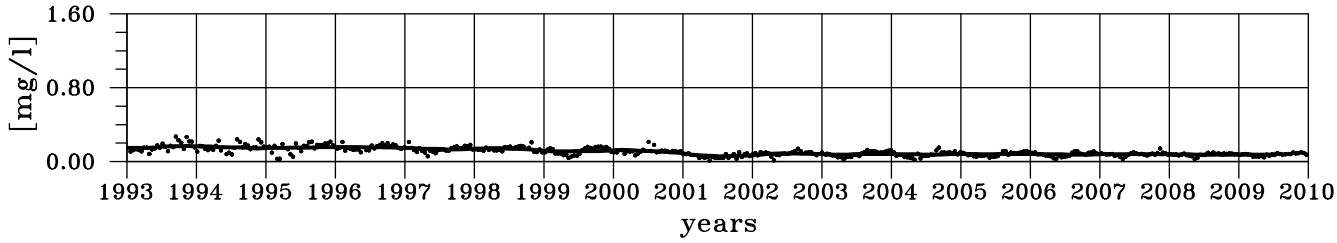
## Phosphate from Nieuwe Waterweg

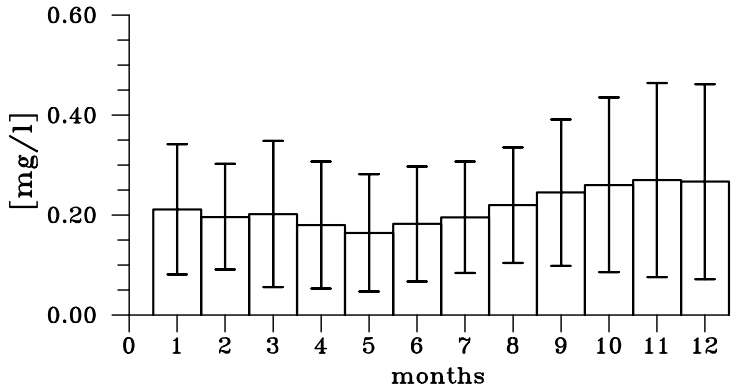
TIME SERIES
number of data: 833
mean: 0.21 mg/l
relative standard deviation: 0.71
minimum: 0.01 mg/l May 22, 2001
maximum: 1.12 mg/l November 21, 1983

LOW PASS
minimum: 0.06 mg/l July 2001
maximum: 0.45 mg/l March 1984

ANNUAL CYCLE
minimum: 0.16 mg/l May, rel. stdev: 0.72
maximum: 0.27 mg/l November, rel. stdev: 0.72



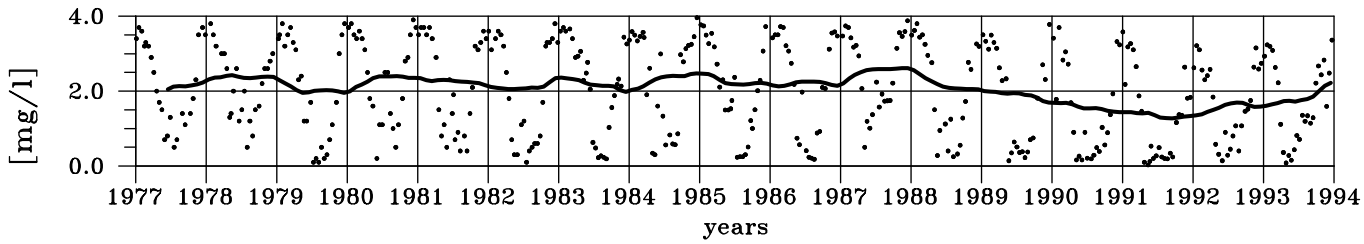



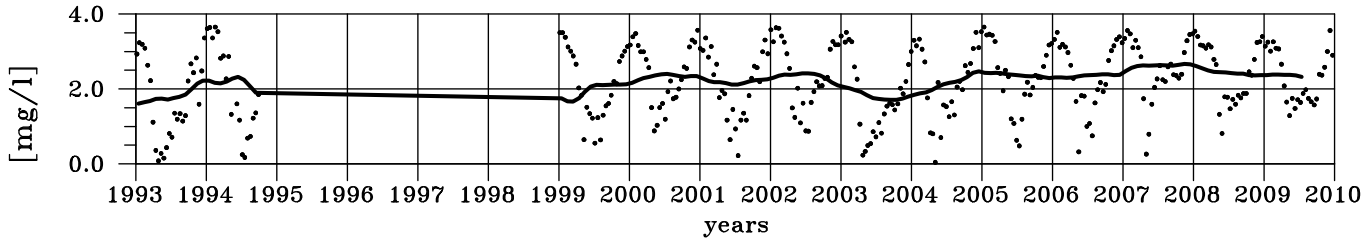
## Silicate from Nieuwe Waterweg

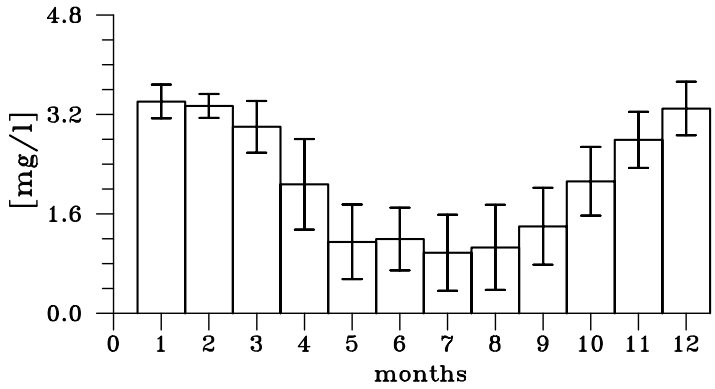
TIME SERIES
number of data: 728
mean: 2.13 mg/l
relative standard deviation: 0.52
minimum: 0.03 mg/l May 13, 1991
maximum: 3.96 mg/l December 18, 1984

LOW PASS
minimum: 1.27 mg/l September 1991
maximum: 2.67 mg/l November 2007

ANNUAL CYCLE
minimum: 0.97 mg/l July, rel. stdev: 0.63
maximum: 3.41 mg/l January, rel. stdev: 0.08



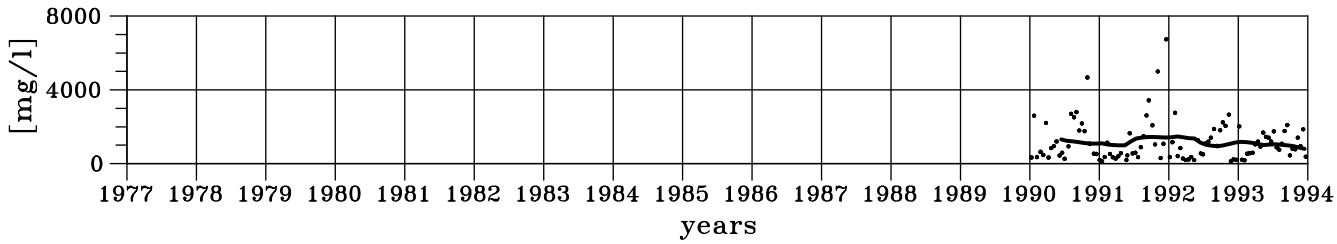



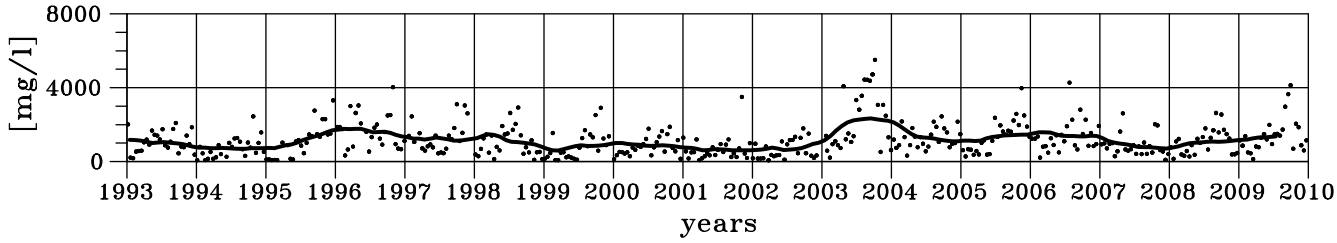
## Chloride from Nieuwe Waterweg

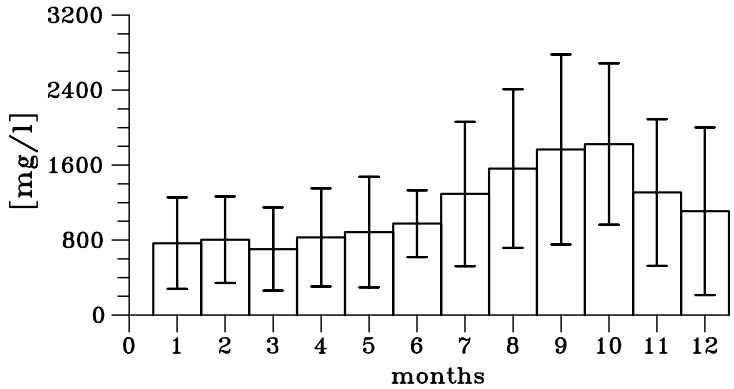
TIME SERIES
number of data: 506
mean: 1165 $mg/l$
relative standard deviation: 0.81
minimum: 68 $mg/l$ March 27, 2002
maximum: 6740 $mg/l$ December 18, 1991

LOW PASS
minimum: 601 $mg/l$ March 1999
maximum: 2347 $mg/l$ September 2003

ANNUAL CYCLE
minimum: 703 $mg/l$ March, rel. stdev: 0.63
maximum: 1824 $mg/l$ October, rel. stdev: 0.47



### 3.2.4 Haringvliet

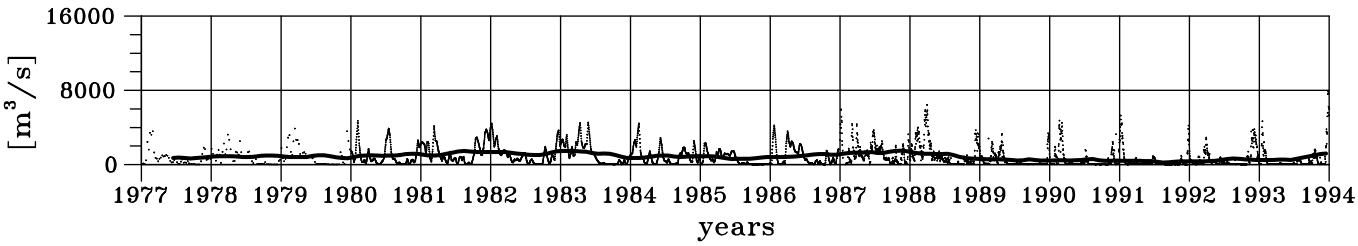
Sampling took place close to the big weir, before the water masses combined from Rhine and Maas enter the North Sea. From 1980 on there were daily data available for the discharge and samples for all the concentrations every two weeks. Even though the samples are taken very near to the North Sea the mean chloride content of about 150 $mg/l$ indicates that there is no mixing of outgoing freshwater with seawater. This results from the fact that the big weir is regulated only for outlet of freshwater which therefore yields no elevated chloride contents. For the year 2004 nitrite concentrations were not available. Therefore for this year we used the nitrate values insted of the sum of nitrate and nitrite concentration.

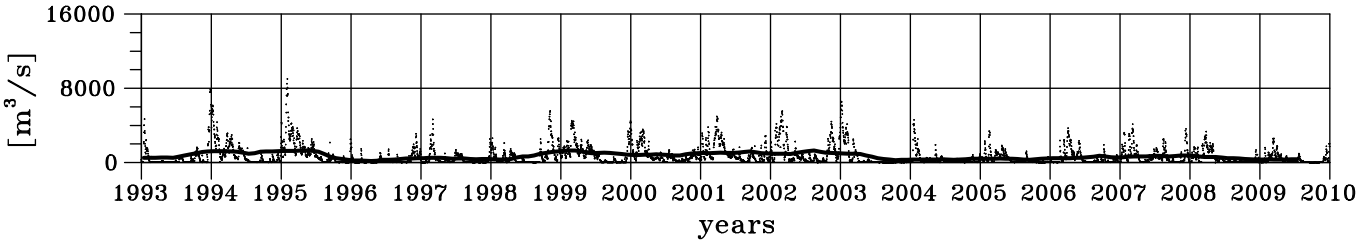
## Discharge from Haringvliet

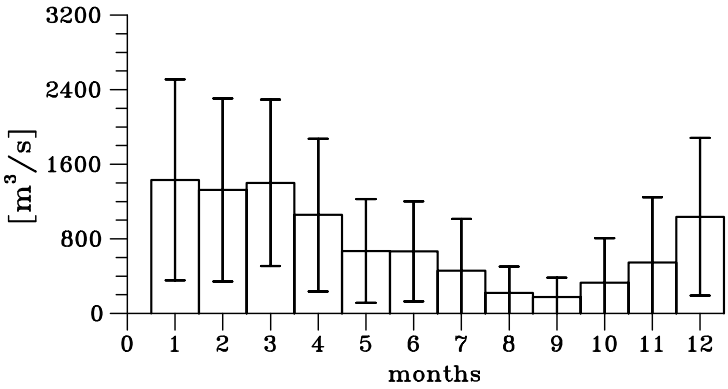
TIME SERIES
number of data: 11083
mean: 765 $m^3/s$
relative standard deviation: 1.34
minimum: 0 $m^3/s$ August 28, 1990
maximum: 9015 $m^3/s$ February 2, 1995

LOW PASS
minimum: 168 $m^3/s$ April 1996
maximum: 1520 $m^3/s$ November 1987

ANNUAL CYCLE
minimum: 176 $m^3/s$ September, rel. stdev: 1.18
maximum: 1432 $m^3/s$ January, rel. stdev: 0.75



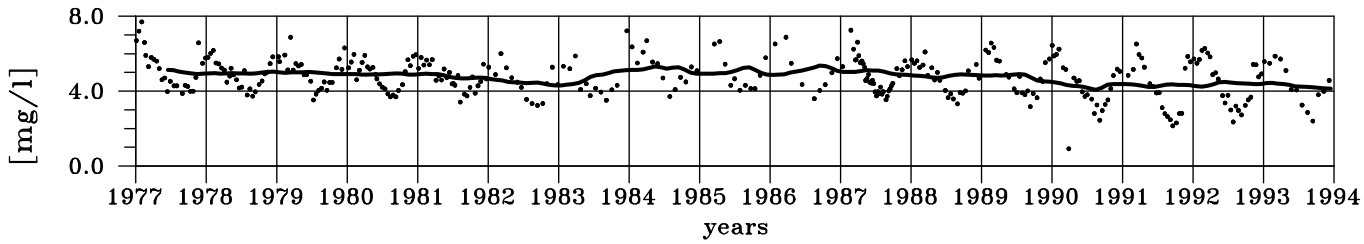



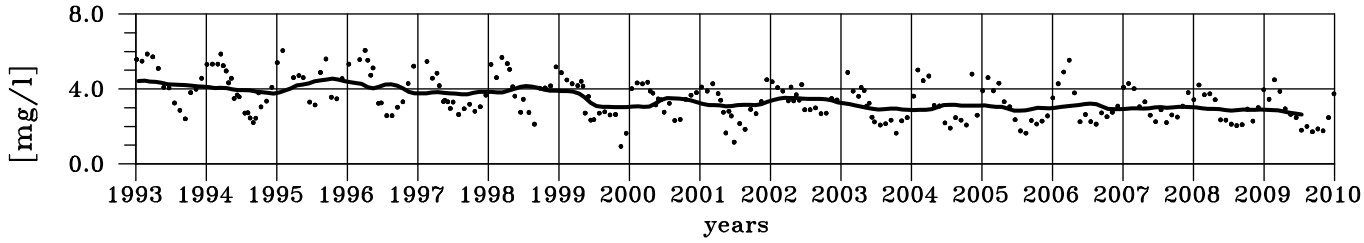
## Total Nitrogen from Haringvliet

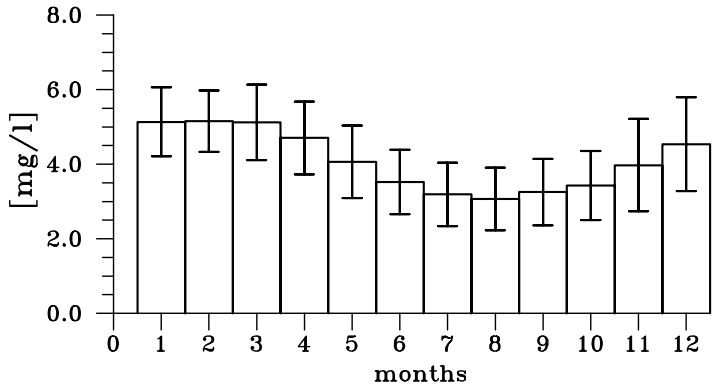
TIME SERIES
number of data: 581
mean: 4.22 mg/l
relative standard deviation: 0.29
minimum: 0.92 mg/l March 28, 1990
maximum: 7.70 mg/l February 1, 1977

LOW PASS
minimum: 2.64 mg/l July 2009
maximum: 5.36 mg/l September 1986

ANNUAL CYCLE
minimum: 3.06 mg/l August, rel. stdev: 0.27
maximum: 5.16 mg/l February, rel. stdev: 0.16



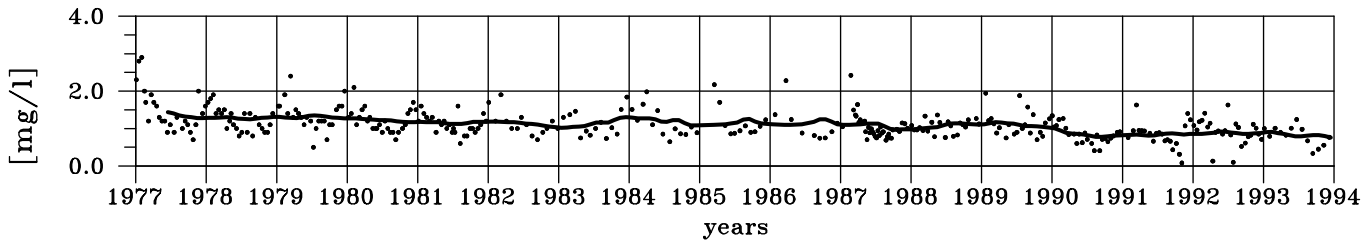



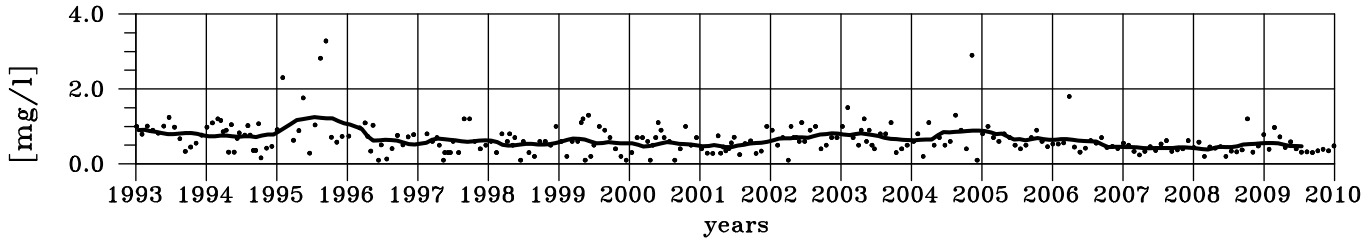
## Kjeldahl Nitrogen from Haringvliet

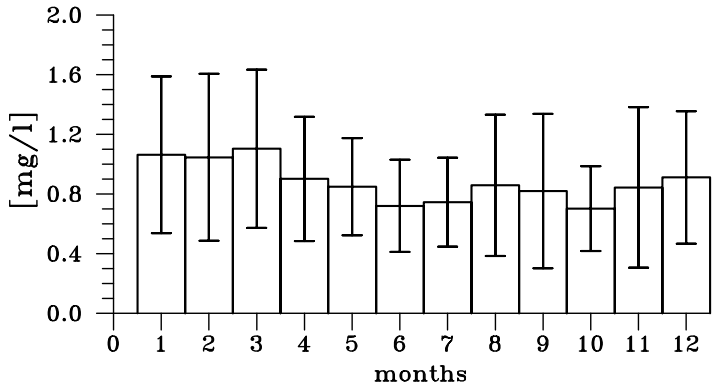
TIME SERIES
number of data: 583
mean: 0.92 mg/l
relative standard deviation: 0.50
minimum: 0.08 mg/l November 4, 1991
maximum: 3.28 mg/l September 12, 1995

LOW PASS
minimum: 0.39 mg/l March 2008
maximum: 1.43 mg/l June 1977

ANNUAL CYCLE
minimum: 0.70 mg/l October, rel. stdev: 0.41
maximum: 1.10 mg/l March, rel. stdev: 0.48



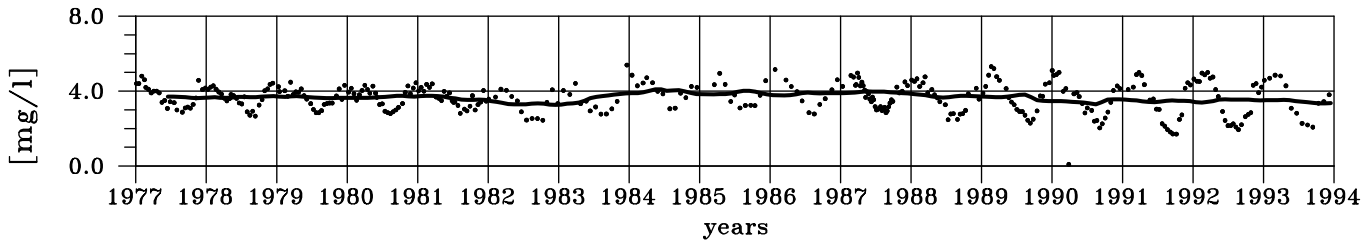



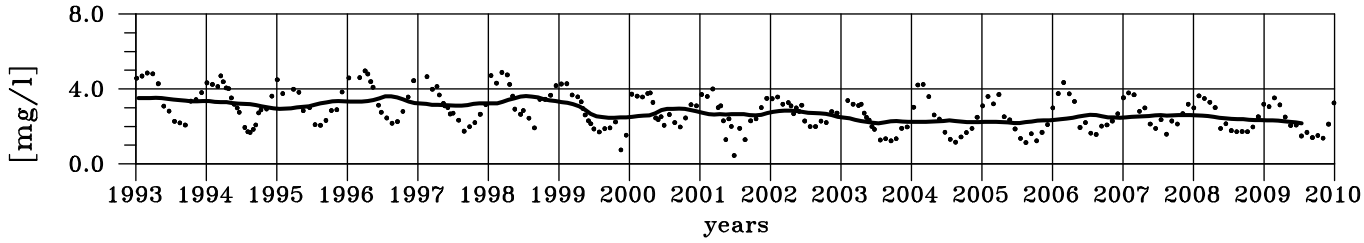
## Nitrate + Nitrite from Haringvliet

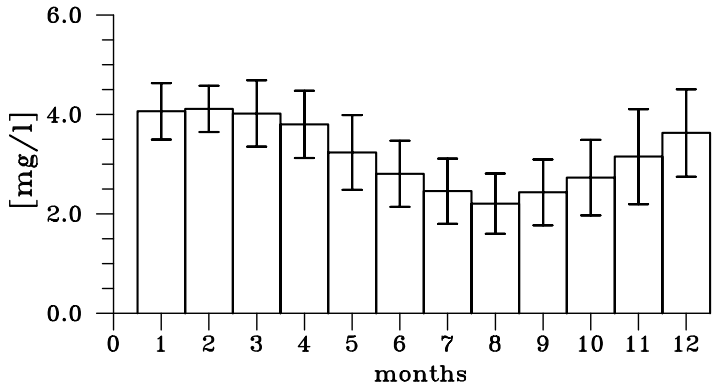
TIME SERIES
number of data: 586
mean: 3.30 mg/l
relative standard deviation: 0.28
minimum: 0.08 mg/l March 28, 1990
maximum: 5.38 mg/l December 20, 1983

LOW PASS
minimum: 2.17 mg/l July 2003
maximum: 4.10 mg/l May 1984

ANNUAL CYCLE
minimum: 2.21 mg/l August, rel. stdev: 0.28
maximum: 4.11 mg/l February, rel. stdev: 0.11



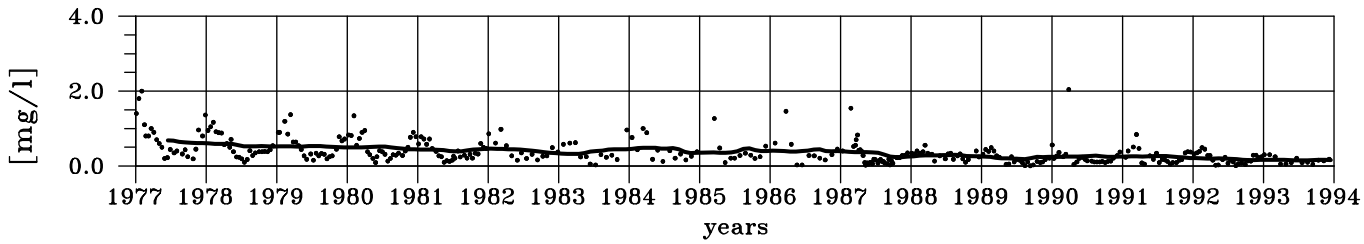



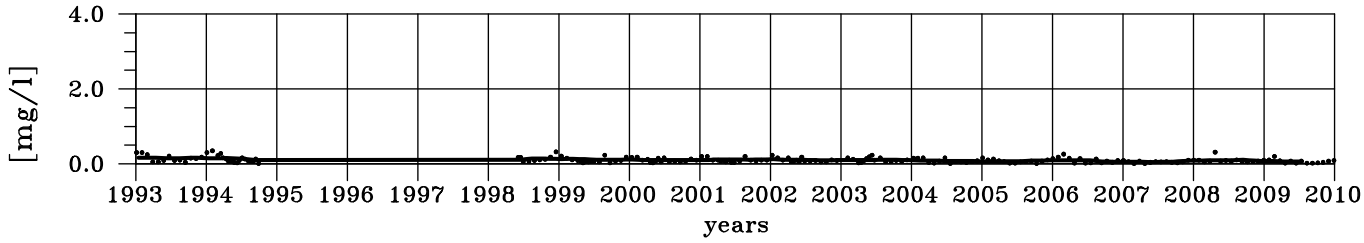
## Ammonium from Haringvliet

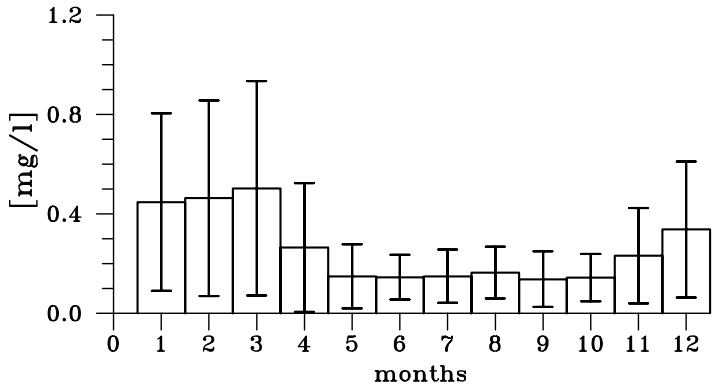
TIME SERIES
number of data: 534
mean: 0.28 mg/l
relative standard deviation: 1.06
minimum: 0.00 mg/l September 11, 1989
maximum: 2.04 mg/l March 28, 1990

LOW PASS
minimum: 0.05 mg/l May 2007
maximum: 0.68 mg/l June 1977

ANNUAL CYCLE
minimum: 0.14 mg/l September, rel. stdev: 0.81
maximum: 0.50 mg/l March, rel. stdev: 0.86



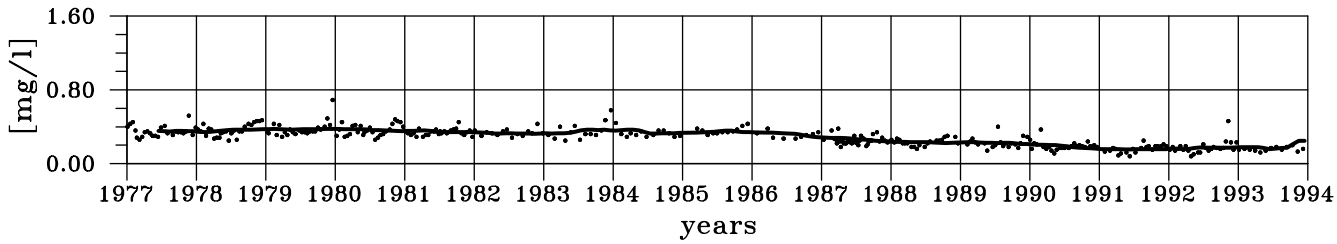



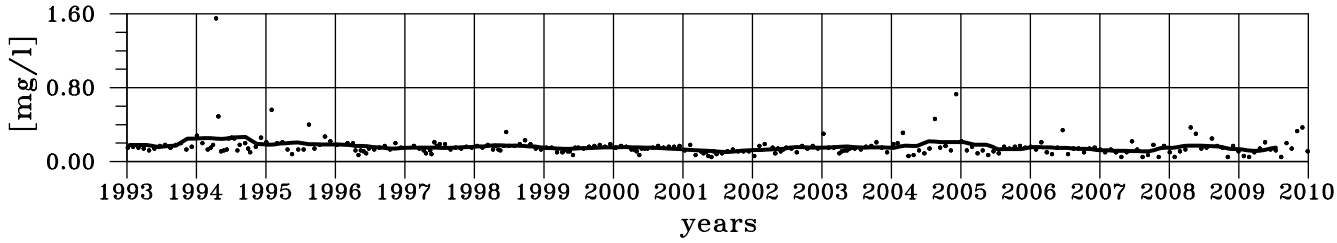
## Total Phosphorus from Haringvliet

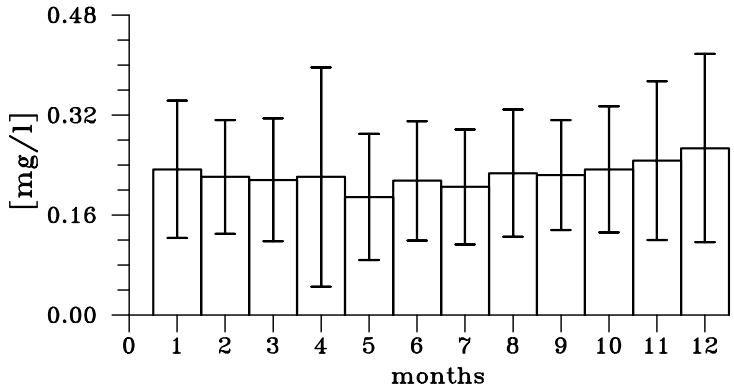
TIME SERIES
number of data: 583
mean: 0.23 mg/l
relative standard deviation: 0.52
minimum: 0.05 mg/l May 31, 2001
maximum: 1.55 mg/l April 14, 1994

LOW PASS
minimum: 0.10 mg/l August 2001
maximum: 0.38 mg/l December 1979

ANNUAL CYCLE
minimum: 0.19 mg/l May, rel. stdev: 0.53
maximum: 0.27 mg/l December, rel. stdev: 0.56



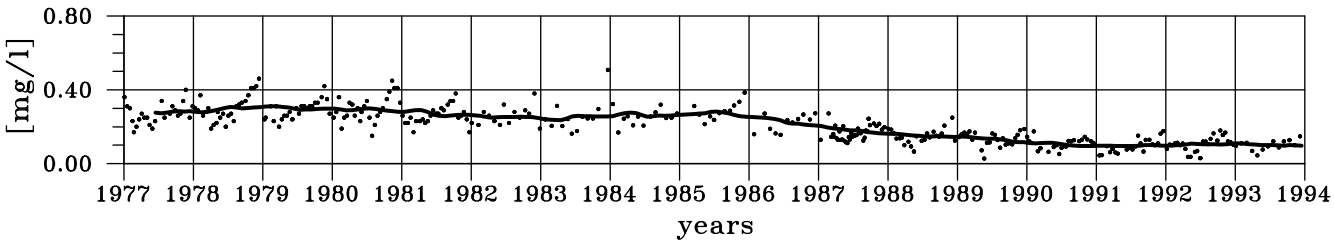



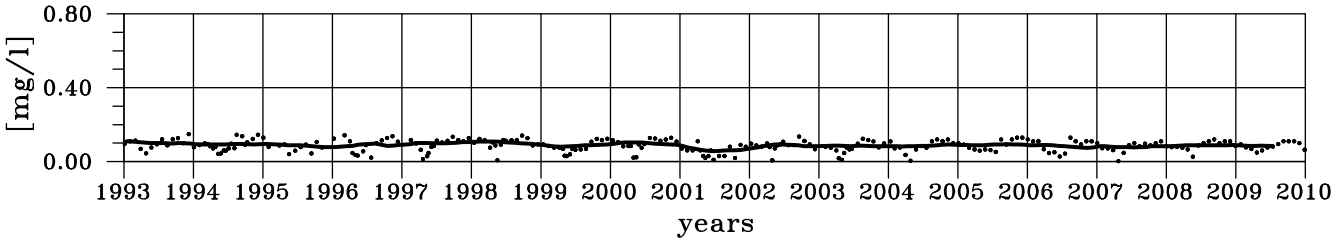
## Phosphate from Haringvliet

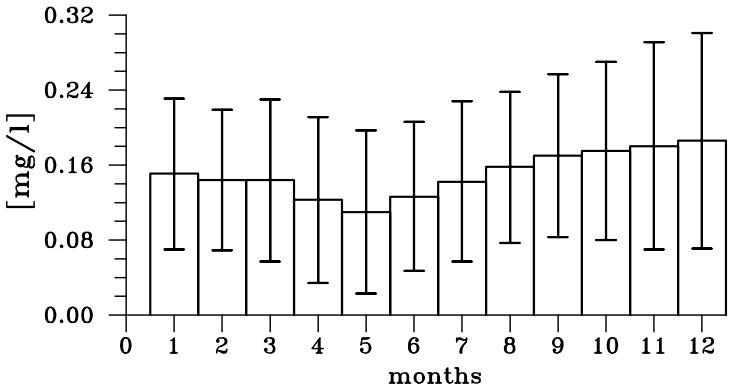
TIME SERIES
number of data: 582
mean: 0.16 mg/l
relative standard deviation: 0.60
minimum: 0.00 mg/l April 24, 2007
maximum: 0.51 mg/l December 20, 1983

LOW PASS
minimum: 0.06 mg/l July 2001
maximum: 0.31 mg/l February 1979

ANNUAL CYCLE
minimum: 0.11 mg/l May, rel. stdev: 0.79
maximum: 0.19 mg/l December, rel. stdev: 0.62



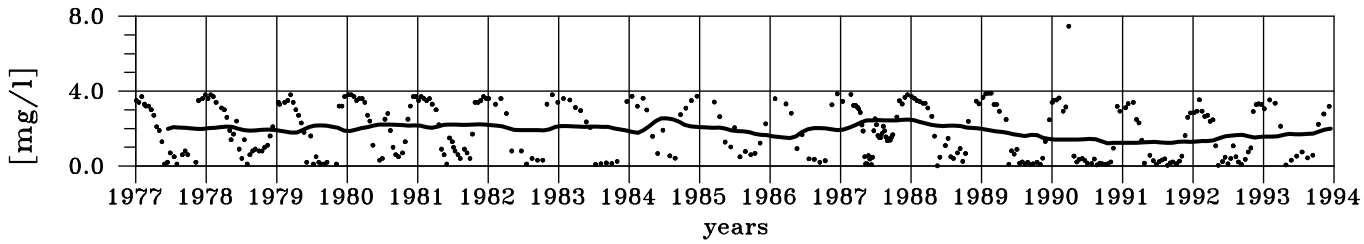



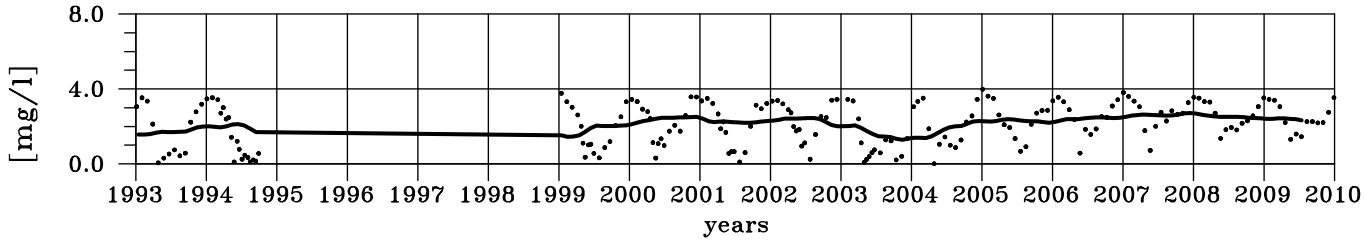
## Silicate from Haringvliet

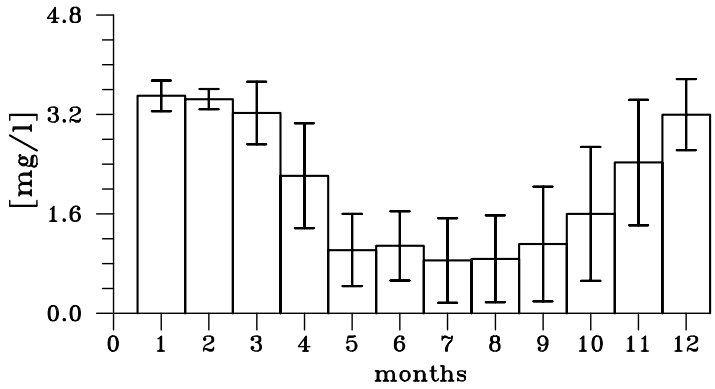
TIME SERIES
number of data: 521
mean: 1.95 mg/l
relative standard deviation: 0.67
minimum: 0.01 mg/l May 16, 1988
maximum: 7.46 mg/l March 28, 1990

LOW PASS
minimum: 1.21 mg/l October 1990
maximum: 2.72 mg/l December 2007

ANNUAL CYCLE
minimum: 0.85 mg/l July, rel. stdev: 0.80
maximum: 3.50 mg/l January, rel. stdev: 0.07



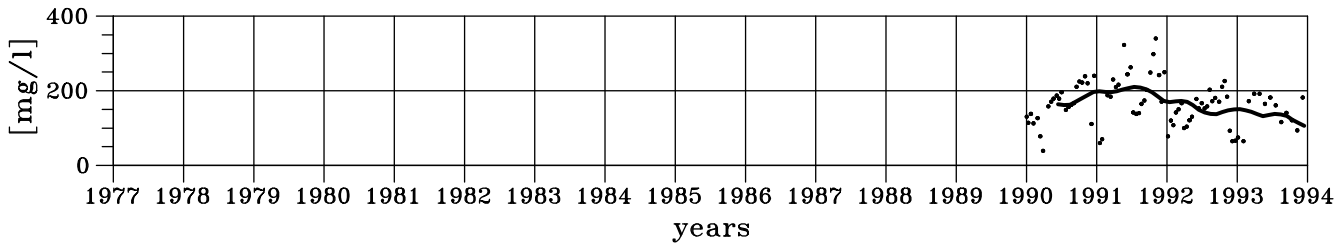



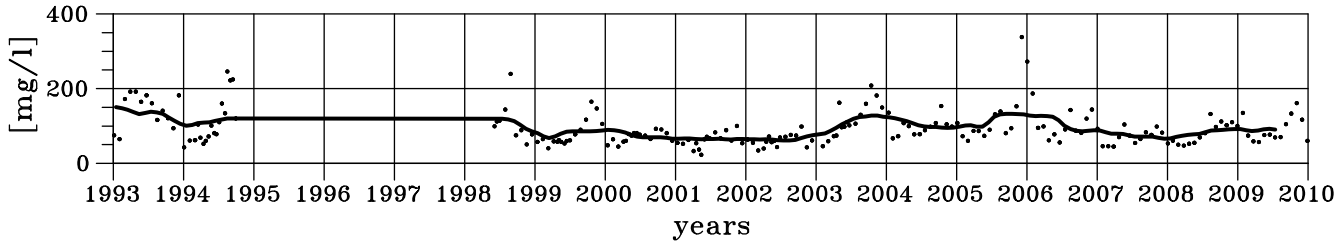
## Chloride from Haringvliet

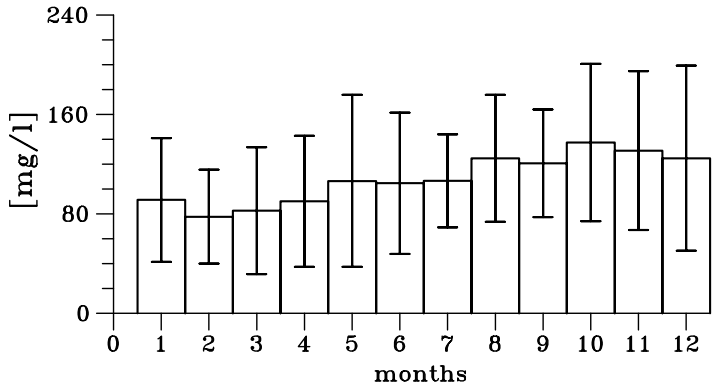
TIME SERIES
number of data: 269
mean: 114 $mg/l$
relative standard deviation: 0.54
minimum: 23 $mg/l$ May 15, 2001
maximum: 340 $mg/l$ November 4, 1991

LOW PASS
minimum: 61 $mg/l$ August 2002
maximum: 210 $mg/l$ July 1991

ANNUAL CYCLE
minimum: 78 $mg/l$ February, rel. stdev: 0.49
maximum: 137 $mg/l$ October, rel. stdev: 0.46



### 3.2.5 River Scheldt

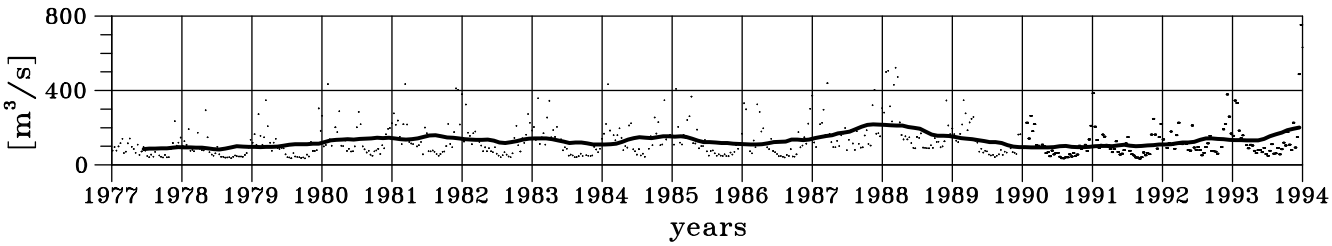
The river Scheldt actually originates from Belgium. RIKZ in the Netherlands could therefore only provide data for the Belgium/Dutch border at location Schaar van Ouden Doel. The discharge data were available every 10 days whereas all concentrations were measured every two weeks. For the year 2004 nitrite concentrations were not available. Therefore for this year we used the nitrate values insted of the sum of nitrate and nitrite concentration.

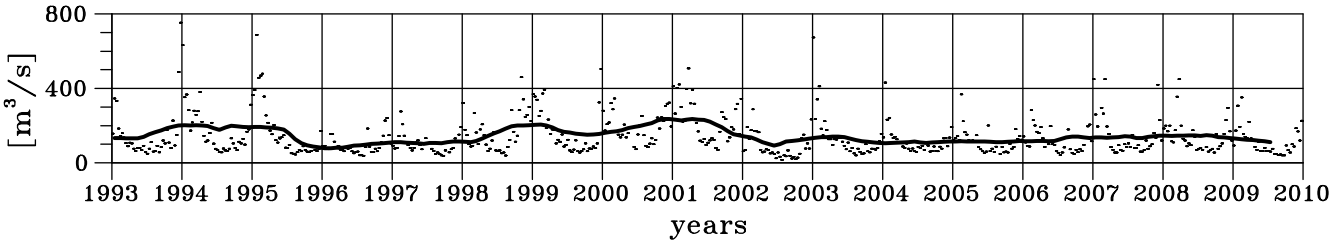
## Discharge from River Scheldt

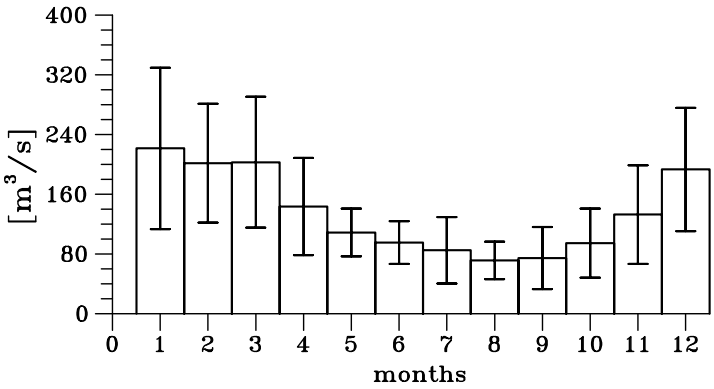
TIME SERIES
number of data: 7768
mean: 137 $m^3/s$
relative standard deviation: 0.72
minimum: 17 $m^3/s$ July 21, 2002
maximum: 753 $m^3/s$ December 21, 1993

LOW PASS
minimum: 79 $m^3/s$ January 1996
maximum: 236 $m^3/s$ April 2001

ANNUAL CYCLE
minimum: 71 $m^3/s$ August, rel. stdev: 0.35
maximum: 221 $m^3/s$ January, rel. stdev: 0.49



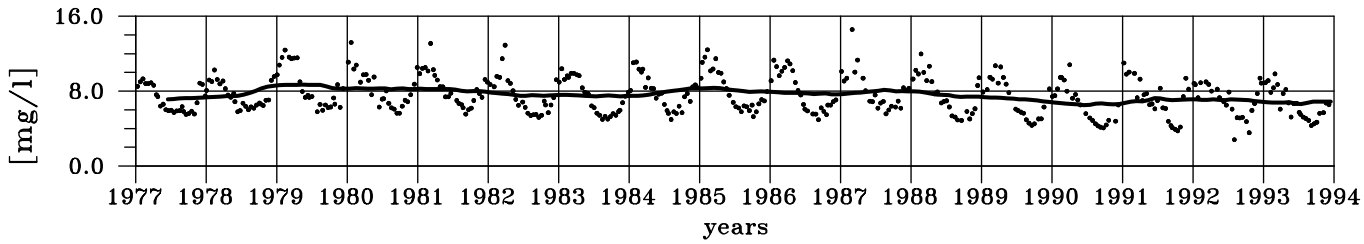



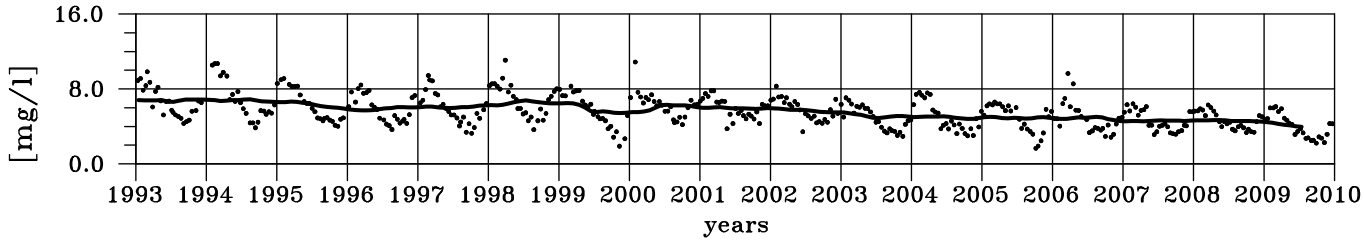
## Total Nitrogen from River Scheldt

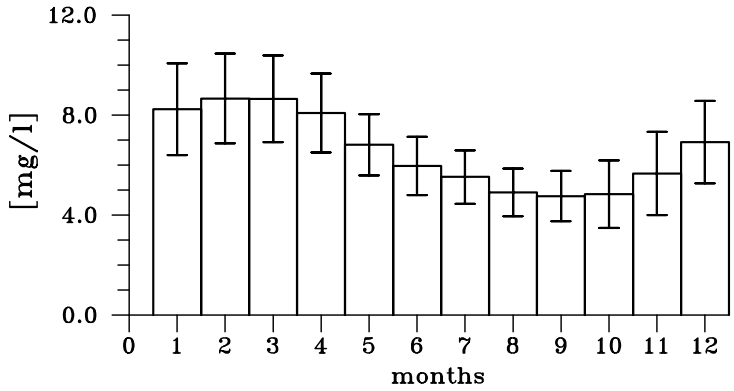
TIME SERIES
number of data: 833
mean: 6.56 mg/l
relative standard deviation: 0.32
minimum: 1.66 mg/l October 6, 2005
maximum: 14.58 mg/l March 2, 1987

LOW PASS
minimum: 3.95 mg/l July 2009
maximum: 8.69 mg/l May 1979

ANNUAL CYCLE
minimum: 4.76 mg/l September, rel. stdev: 0.21
maximum: 8.66 mg/l February, rel. stdev: 0.21



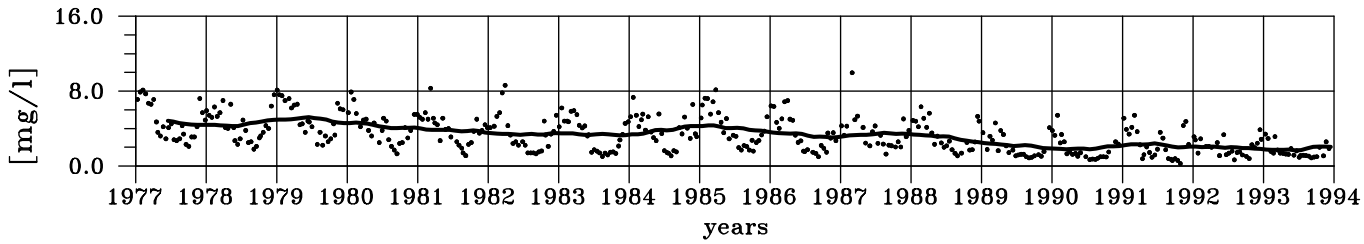



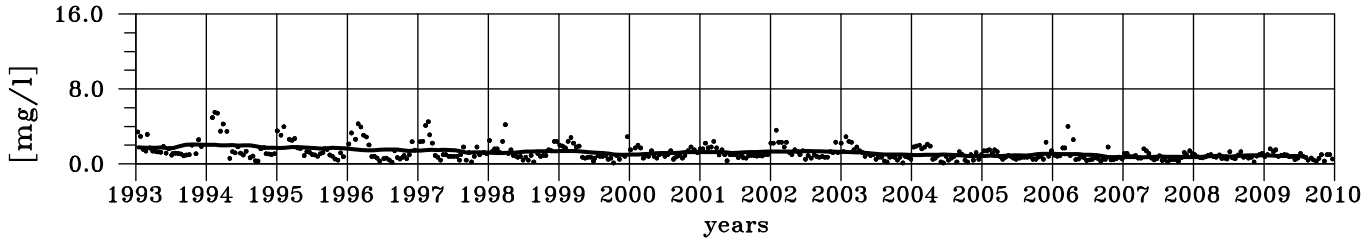
## Kjeldahl Nitrogen from River Scheldt

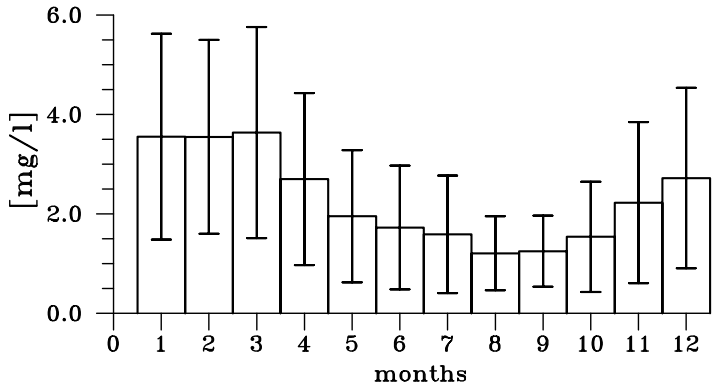
TIME SERIES
number of data: 838
mean: 2.29 mg/l
relative standard deviation: 0.80
minimum: 0.10 mg/l October 11, 1999
maximum: 9.96 mg/l March 2, 1987

LOW PASS
minimum: 0.71 mg/l April 2007
maximum: 5.20 mg/l June 1979

ANNUAL CYCLE
minimum: 1.21 mg/l August, rel. stdev: 0.62
maximum: 3.64 mg/l March, rel. stdev: 0.58



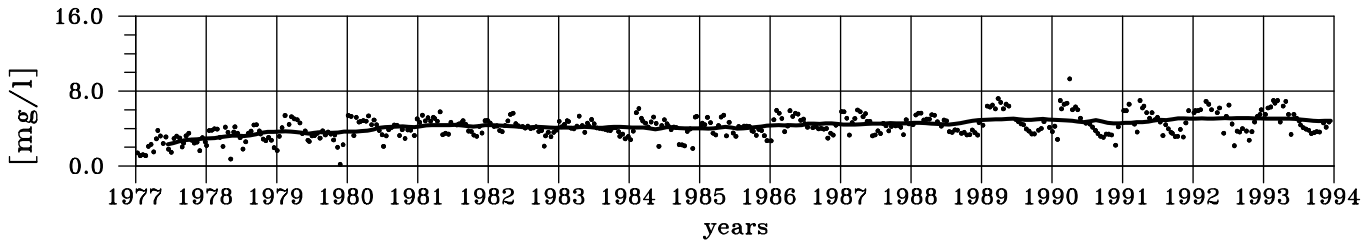



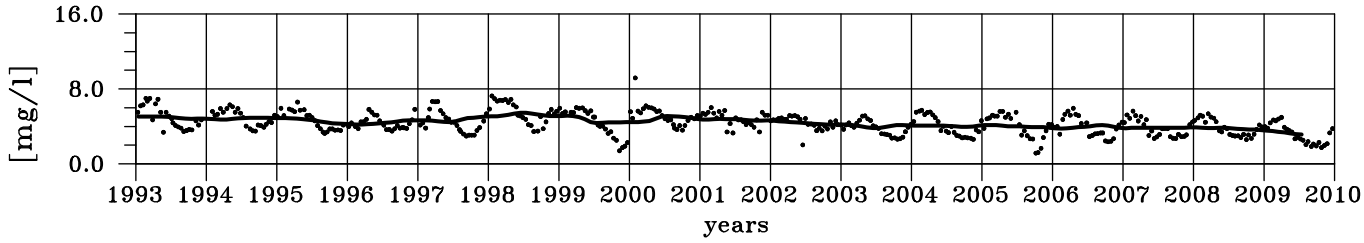
## Nitrate + Nitrite from River Scheldt

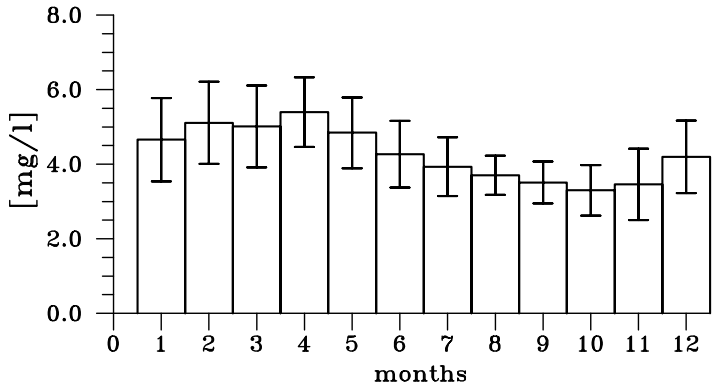
TIME SERIES
number of data: 843
mean: 4.26 mg/l
relative standard deviation: 0.28
minimum: 0.16 mg/l November 26, 1979
maximum: 9.30 mg/l April 2, 1990

LOW PASS
minimum: 2.32 mg/l June 1977
maximum: 5.47 mg/l June 1998

ANNUAL CYCLE
minimum: 3.30 mg/l October, rel. stdev: 0.21
maximum: 5.39 mg/l April, rel. stdev: 0.17



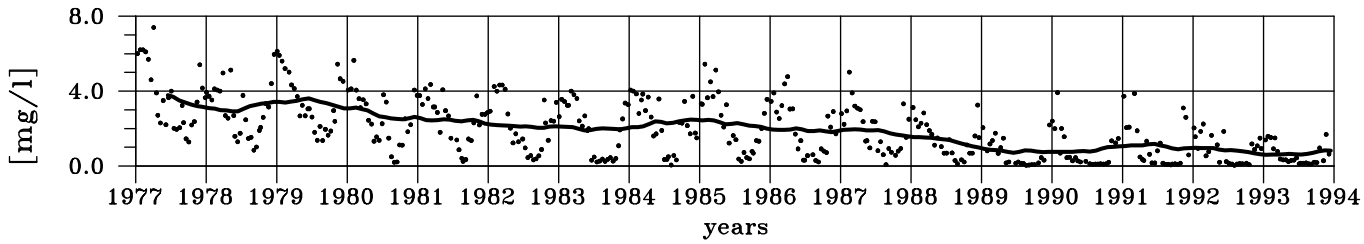



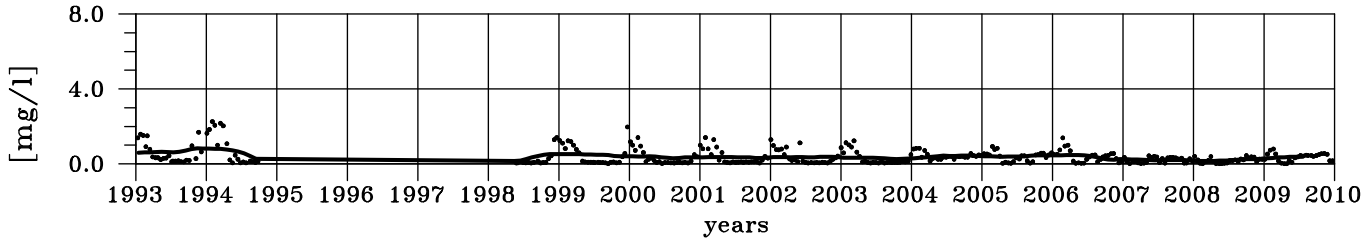
## Ammonium from River Scheldt

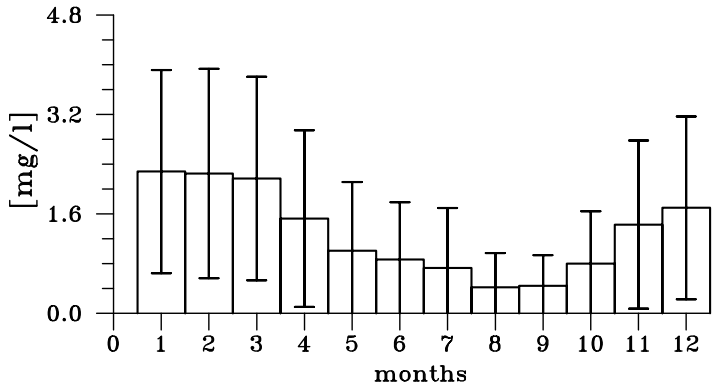
TIME SERIES
number of data: 758
mean: 1.30 mg/l
relative standard deviation: 1.10
minimum: 0.01 mg/l September 13, 1999
maximum: 7.40 mg/l April 4, 1977

LOW PASS
minimum: 0.15 mg/l April 2008
maximum: 3.78 mg/l June 1977

ANNUAL CYCLE
minimum: 0.42 mg/l August, rel. stdev: 1.31
maximum: 2.28 mg/l January, rel. stdev: 0.72



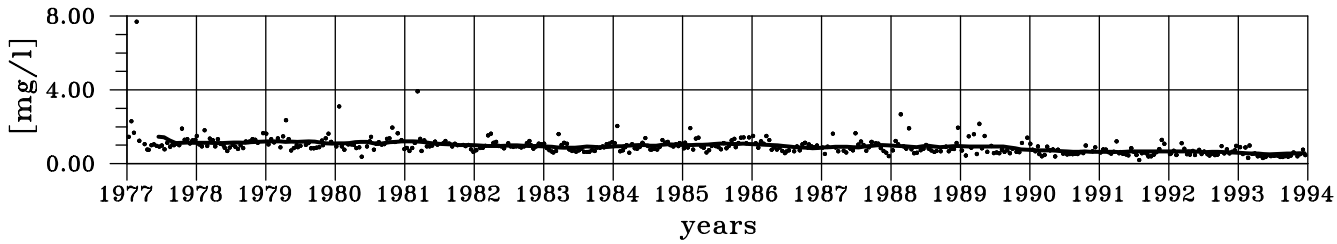



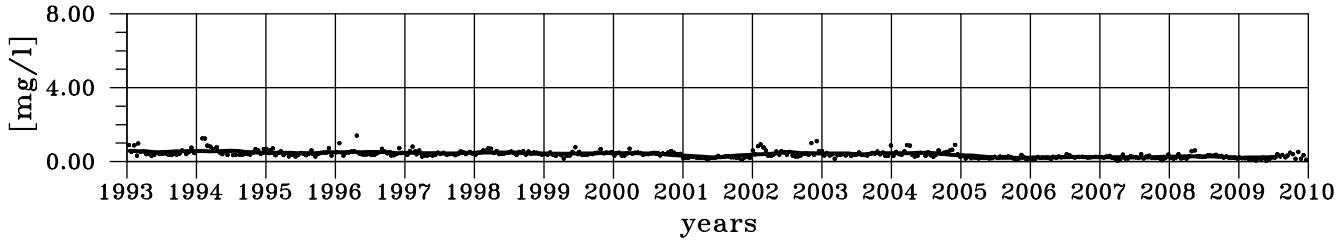
## Total Phosphorus from River Scheldt

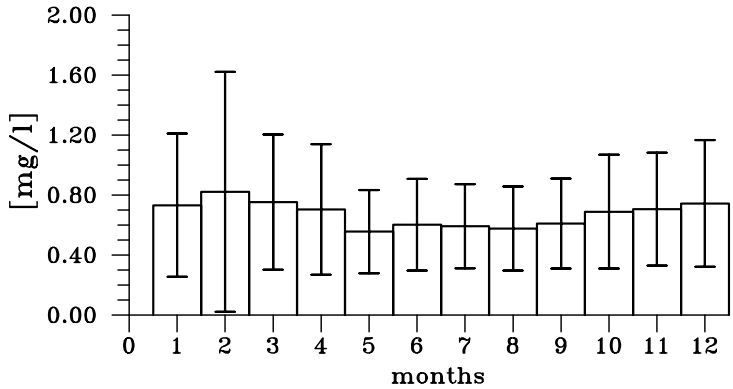
TIME SERIES
number of data: 839
mean: 0.67 mg/l
relative standard deviation: 0.71
minimum: 0.05 mg/l April 4, 2007
maximum: 7.70 mg/l February 21, 1977

LOW PASS
minimum: 0.20 mg/l September 2005
maximum: 1.46 mg/l June 1977

ANNUAL CYCLE
minimum: 0.56 mg/l May, rel. stdev: 0.50
maximum: 0.82 mg/l February, rel. stdev: 0.97



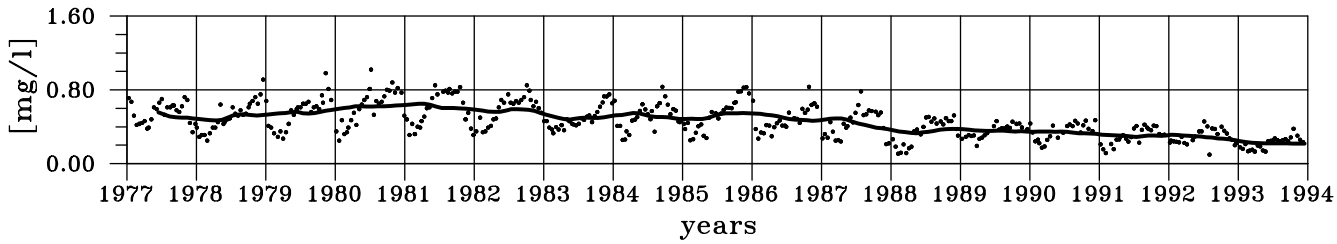



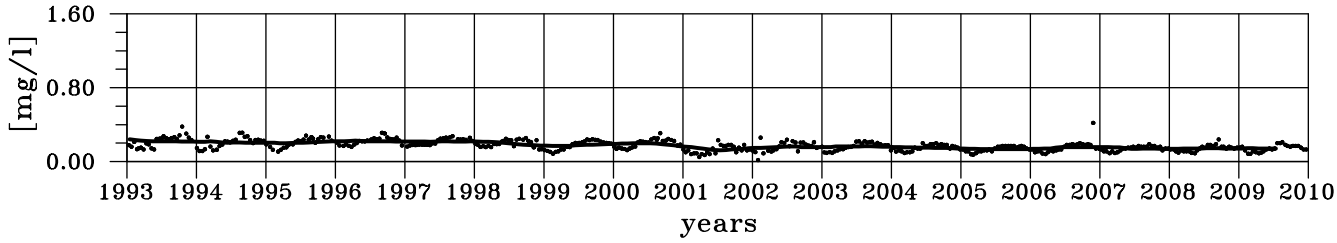
## Phosphate from River Scheldt

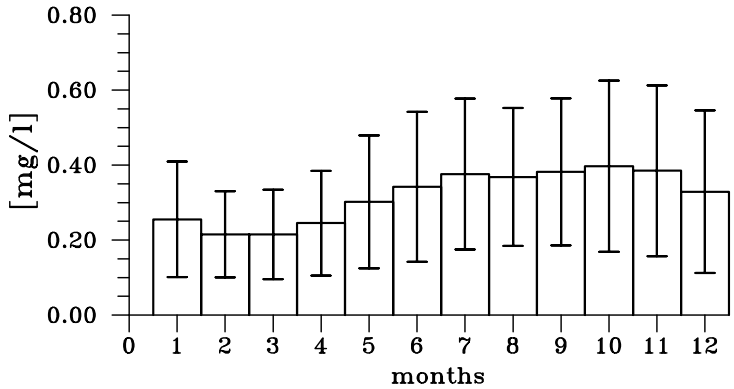
TIME SERIES
number of data: 844
mean: 0.32 mg/l
relative standard deviation: 0.62
minimum: 0.02 mg/l January 31, 2002
maximum: 1.02 mg/l July 7, 1980

LOW PASS
minimum: 0.12 mg/l July 2001
maximum: 0.65 mg/l April 1981

ANNUAL CYCLE
minimum: 0.21 mg/l March, rel. stdev: 0.55
maximum: 0.40 mg/l October, rel. stdev: 0.57



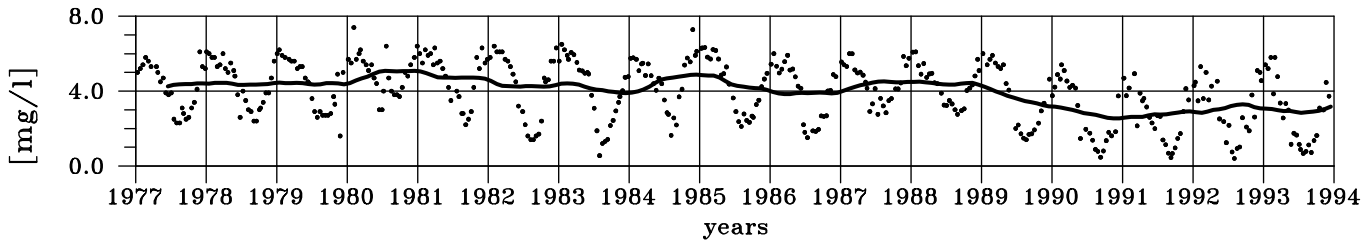



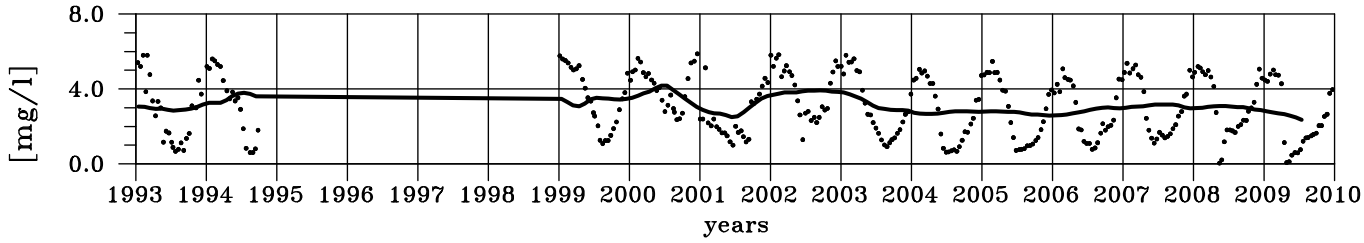
## Silicate from River Scheldt

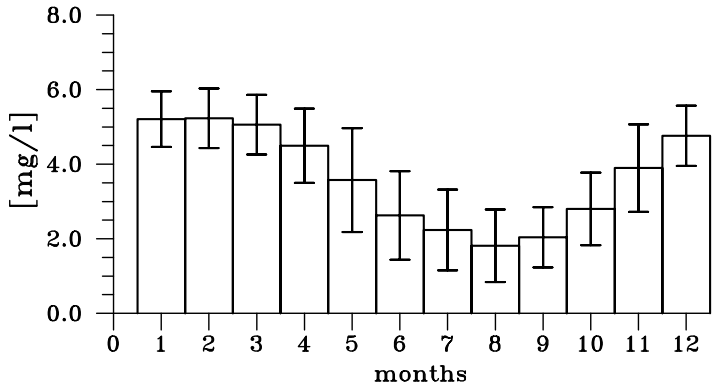
TIME SERIES
number of data: 741
mean: 3.63 mg/l
relative standard deviation: 0.45
minimum: 0.04 mg/l May 15, 2008
maximum: 7.40 mg/l February 4, 1980

LOW PASS
minimum: 2.35 mg/l July 2009
maximum: 5.09 mg/l July 1980

ANNUAL CYCLE
minimum: 1.81 mg/l August, rel. stdev: 0.54
maximum: 5.23 mg/l February, rel. stdev: 0.15



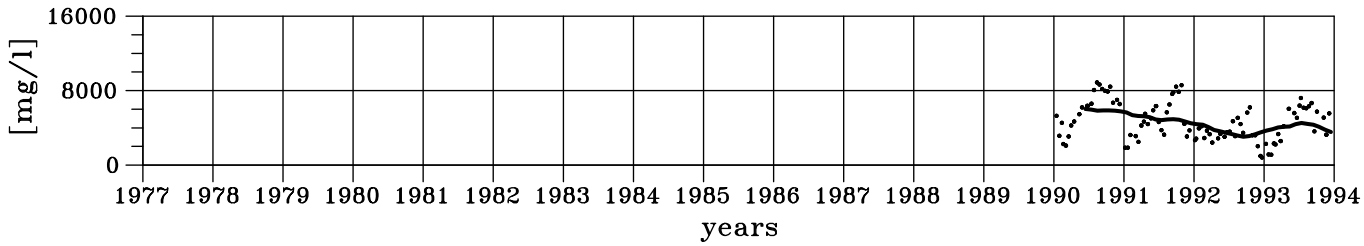



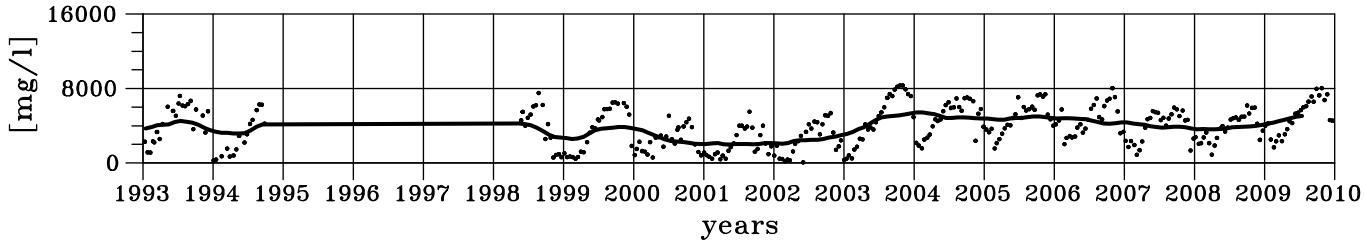
## Chloride from River Scheldt

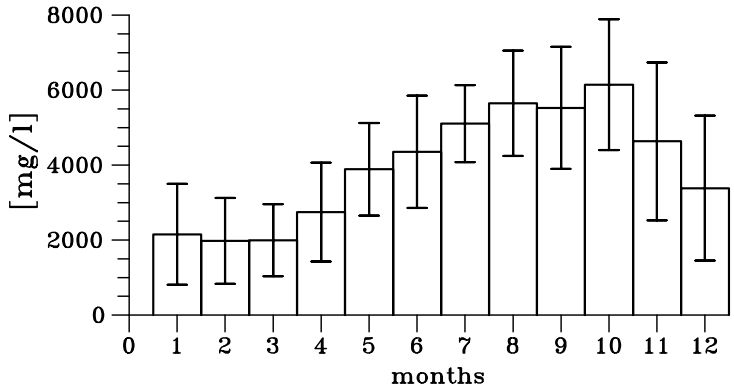
TIME SERIES
number of data: 412
mean: 4010 $mg/l$
relative standard deviation: 0.53
minimum: 61 $mg/l$ June 3, 2002
maximum: 8880 $mg/l$ August 13, 1990

LOW PASS
minimum: 1968 $mg/l$ May 2001
maximum: 6026 $mg/l$ June 1990

ANNUAL CYCLE
minimum: 1979 $mg/l$ February, rel. stdev: 0.58
maximum: 6145 $mg/l$ October, rel. stdev: 0.28



# 4 Methods for river load estimation

In this chapter a method for calculating daily nutrient loads will be presented. Based on a comparison of different methods for the calculation of yearly load estimates by De Vries & Klavers (1994), an appropriate method for calculating daily river loads of nutrients was deduced (de Vries, pers. com.) and the adopted method will be demonstrated.

There are several problems when calculating load estimates for substances transported by a river. Firstly there exists a spatially inhomogeneous distribution of the concentration across the river. A single inlet of kali salt, e.g. from an incoming river at the bank of the river Elbe, can be identified by a cross section tenth of kilometers downstream of the inlet (Bergemann, pers. comm.). Since in most cases only point measurements are available, we have to ignore this problem by simply assuming a spatially homogeneous distribution across the river. We therefore take the available discrete point measurements as representative for the whole cross-section of the river.

Secondly, one cannot expect to represent the inhomogenities of concentration values in time by one, two or four measurements per month. The question of temporal interpolation of concentration measurements in order to calculate yearly load estimates is dealt with in the paper by De Vries & Klavers (1994). For these yearly load estimates 7 interpolation methods were tested by De Vries & Klavers (1994), of which 3 will be discussed here. Finally a modified method for the use of calculating daily load estimates and the resulting formulae will be presented, using the following abbreviations:

| | |
|---|---|
| $C_i$: | mean concentration at day i |
| $Q_i$: | mean discharge at day i |
| $C_i^{LI}$: | $C_i$ if a concentration value is available for day i, otherwise linearly temporal interpolated concentration value |
| $Q_i^{LI}$: | $Q_i$ if a discharge value is available for day i, otherwise linearly temporal interpolated discharge value |
| $n$: | number of days per year with concentration values |
| $m$: | number of days per year with discharge values |
| $k$: | number of days per year |
| $L$: | yearly load |

(1) **Simple method**, using mean annual values for concentration and discharge

$$L = k(\frac{1}{n}\sum_{i=1}^{n} C_i)(\frac{1}{m}\sum_{i=1}^{m} Q_i)$$

(2) **Direct method**, using daily discharge and concentration values when available

$$L = \frac{k}{n} \sum_{i=1}^{n} C_i \cdot Q_i$$

For method (2) the discharge values have to be available for the same day as the concentration measurements. Only when both data are available for the same day the product for that day can be calculated.

(3) **Linear interpolation method**, using interpolated concentrations

$$L = \sum_{i=1}^{k} C_i^{LI} Q_i$$

For method (3) it has to be assumed that daily discharge values are available. Since the discharge data as presented in chapter 3 are not always available on a daily basis for all rivers an extended method of the linear interpolation method is presented:

**(4) Double linear interpolation method**, using daily interpolated values for discharge and concentration

$$L = \sum_{i=1}^{k} C_i^{LI} Q_i^{LI}$$

De Vries & Klavers (1994) investigated the quality of their load estimates using the terms accuracy and precision. Accuracy determines the distance from the yearly load as it would be measured. Precision is determined by the scattering of repeated calculations with randomly chosen days of measurement.

For the calculation of daily loads a maximum of temporal resolution and a maximum of accuracy and precision have to be combined. Because of this the **Double linear interpolation method** (4) has been chosen. The i-th term of the sum is identified with the daily load $L_i$

$$L_i = C_i^{LI} Q_i^{LI}$$

The **Simple method** (1) would not be appropriate as it smears out all temporal variability while the **Direct method** (2) has the disadvantage that a lot of discharge as well as concentration measurements have to be ignored. When daily values of discharge are available the discussion by De Vries & Klavers (1994) concerning the **Linear interpolation method** (3) can be adopted: In case of positive correlation between concentration and discharge the load will be underestimated. In case of negative correlation the load will be overestimated. If the concentration does not vary with varying discharge this method results in load estimates which would be similar to those resulting from calculations with daily concentration measurements. The reason for the systematical under- or overestimation results from the frequency distribution of the discharge values of almost all rivers: it is not symmetric and exhibits rare large events.

In the first report (Lenhart *et al.*, 1996) the correlation between discharge and nutrient concentration had been plotted for all the parameters. From these figures one can see that the correlation between nitrogen compounds and discharge is weakly positiv in most cases. Phosphorus compounds show in most cases a negative correlation. Silicate exhibits in most cases strongly positiv correlation. Following the discussion above we can conclude that the load estimates of nitrogen compounds will not result in a systematic error. The load estimates of phosphorus compounds may be overestimated. Silicate loads may be underestimated.

In the following chapter the resulting time series of daily load estimates together with the low-pass filtered curve will be presented in combination with their statistical properties, as it was done for the presentation of the raw data. In a separate figure, the climatological monthly means are added. In order to allow comparisons with literature values, e.g. the Quality Status Report 2000 (OSPAR, 2000), the results of the daily load calculations are given as yearly integrals for all available years.

Two final comments should be made. First, in the calculation of the mass, the units refer to the relevant elements N, P or Si, e.g. tons $NO_3 - N$ per day. Second, there are differences between the presented data and those from Lenhart *et al.* (1996), which are related to zero values for the load minimum. Since these values stem from zero discharge values which enter the load calculation, the related zero loads in this report should be taken as the realistic ones. Additionally negative discharge values for the Nieuwe Waterweg in 1999 and 2000 exist. They represent short events of North Sea outflow into the river system. These events could be found in the time series of discharge illustrated. The corresponding loads however were defined as zero.

# 5 Resulting river load estimates

## 5.1 Loads of River Elbe

### Total Nitrogen load for River Elbe

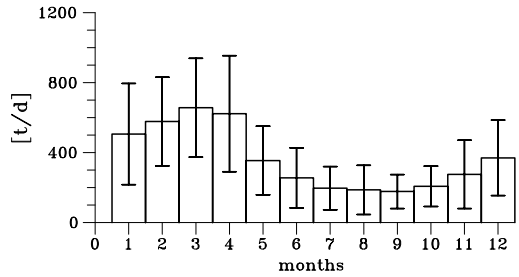
ANNUAL LOADS

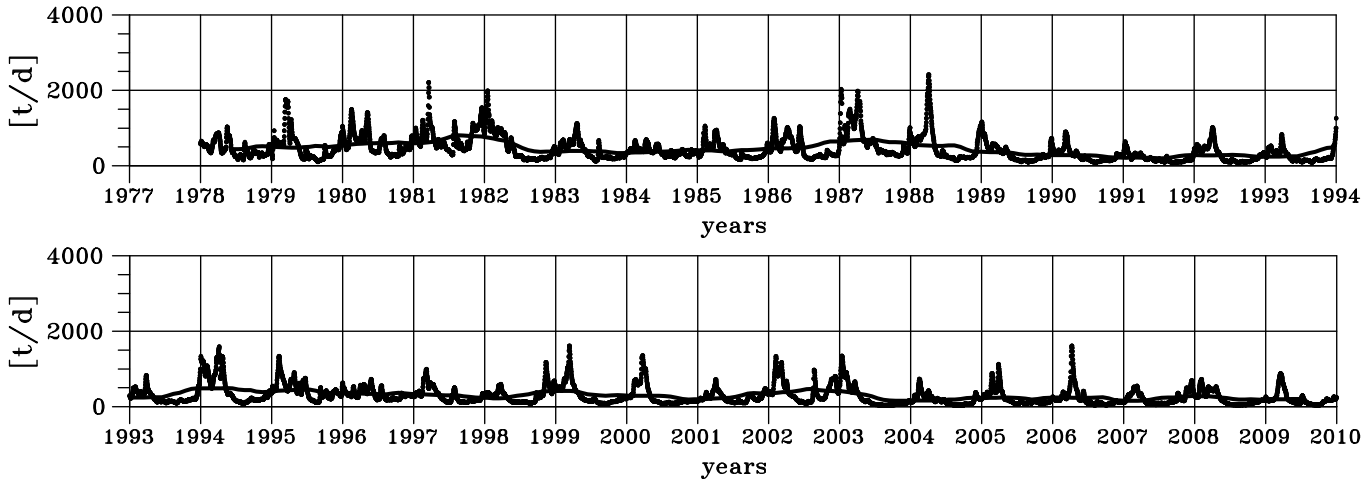
| year | kt/y | year | kt/y | year | kt/y | year | kt/y | year | kt/y |
|---|---|---|---|---|---|---|---|---|---|
| | | 1984 | 138.3 | 1991 | 72.0 | 1998 | 110.0 | 2005 | 84.2 |
| 1978 | 160.6 | 1985 | 140.3 | 1992 | 106.0 | 1999 | 116.7 | 2006 | 84.0 |
| 1979 | 182.6 | 1986 | 168.5 | 1993 | 94.3 | 2000 | 103.7 | 2007 | 82.1 |
| 1980 | 217.4 | 1987 | 255.2 | 1994 | 175.1 | 2001 | 89.6 | 2008 | 76.8 |
| 1981 | 273.7 | 1988 | 195.9 | 1995 | 165.3 | 2002 | 157.8 | 2009 | 74.6 |
| 1982 | 185.1 | 1989 | 119.6 | 1996 | 121.8 | 2003 | 91.3 | | |
| 1983 | 140.4 | 1990 | 97.7 | 1997 | 109.3 | 2004 | 66.0 | | |

TIME SERIES
mean: 353.1 t/d
relative standard deviation: 0.85
minimum: 31.4 t/d August 18, 2003
maximum: 2419.3 t/d April 5, 1988

LOW PASS
minimum: 156.7 t/d January 2007
maximum: 805.6 t/d August 1981

ANNUAL CYCLE
minimum: 177.4 t/d September, rel. stdev: 0.55
maximum: 656.2 t/d March, rel. stdev: 0.43



## Nitrate load for River Elbe

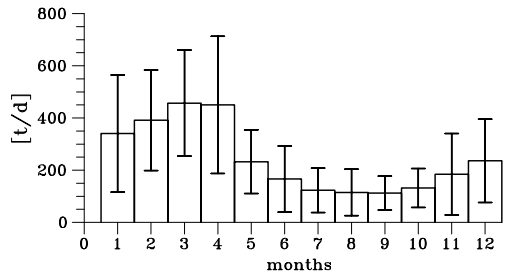
ANNUAL LOADS

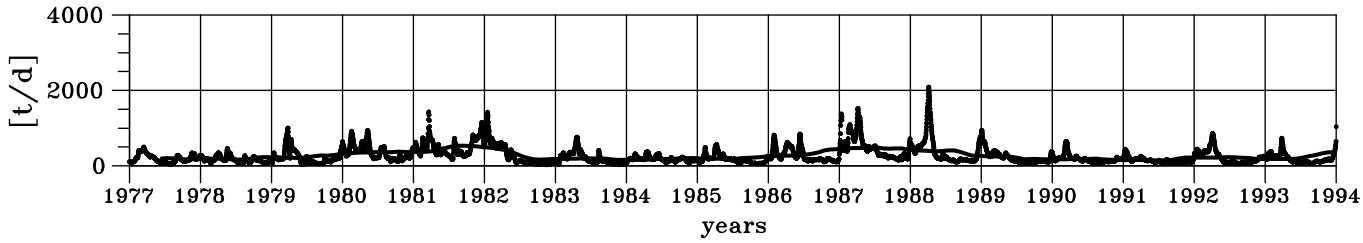
| year | kt/y | year | kt/y | year | kt/y | year | kt/y | year | kt/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 71.0 | 1984 | 67.5 | 1991 | 51.5 | 1998 | 81.0 | 2005 | 70.8 |
| 1978 | 62.1 | 1985 | 63.9 | 1992 | 83.8 | 1999 | 87.0 | 2006 | 73.5 |
| 1979 | 83.1 | 1986 | 101.5 | 1993 | 69.7 | 2000 | 79.6 | 2007 | 67.6 |
| 1980 | 131.8 | 1987 | 179.4 | 1994 | 132.6 | 2001 | 65.2 | 2008 | 61.1 |
| 1981 | 180.6 | 1988 | 145.0 | 1995 | 127.8 | 2002 | 127.3 | 2009 | 60.9 |
| 1982 | 102.0 | 1989 | 79.3 | 1996 | 87.9 | 2003 | 77.4 | | |
| 1983 | 70.3 | 1990 | 65.9 | 1997 | 78.5 | 2004 | 54.0 | | |

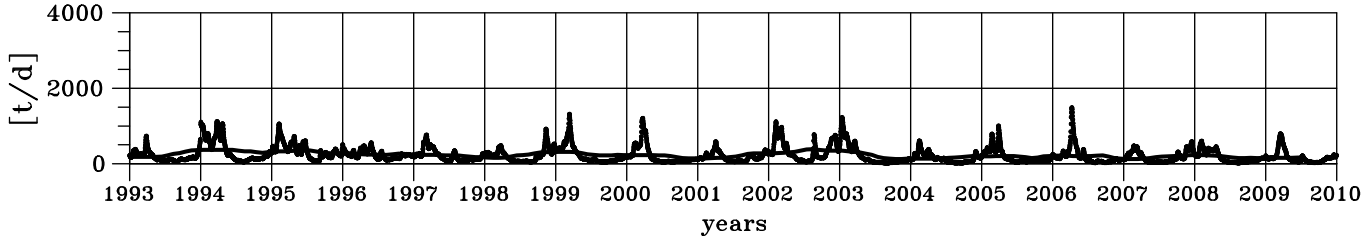
TIME SERIES
mean: 244.0 t/d
relative standard deviation: 0.90
minimum: 15.6 t/d September 1, 2003
maximum: 2090.8 t/d April 5, 1988

LOW PASS
minimum: 125.2 t/d February 2007
maximum: 537.7 t/d August 1981

ANNUAL CYCLE
minimum: 112.5 t/d September, rel. stdev: 0.58
maximum: 456.9 t/d March, rel. stdev: 0.44



## Ammonium load for River Elbe

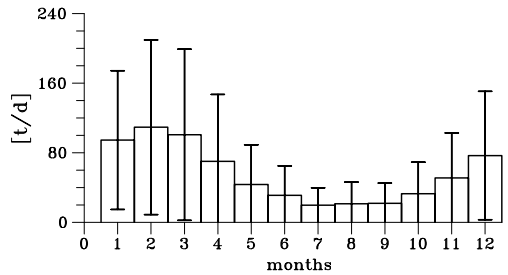
ANNUAL LOADS

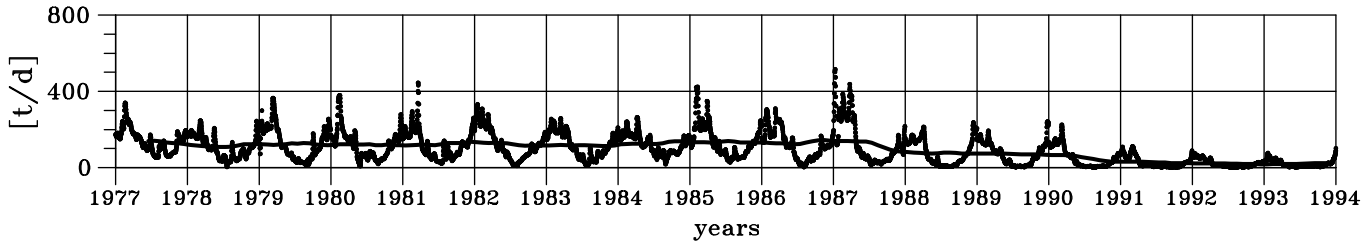
| year | kt/y | year | kt/y | year | kt/y | year | kt/y | year | kt/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 51.3 | 1984 | 45.0 | 1991 | 10.2 | 1998 | 4.5 | 2005 | 3.8 |
| 1978 | 39.3 | 1985 | 49.7 | 1992 | 7.9 | 1999 | 4.2 | 2006 | 4.4 |
| 1979 | 46.3 | 1986 | 43.7 | 1993 | 7.1 | 2000 | 3.4 | 2007 | 3.2 |
| 1980 | 43.7 | 1987 | 49.2 | 1994 | 7.7 | 2001 | 4.0 | 2008 | 2.9 |
| 1981 | 43.3 | 1988 | 28.8 | 1995 | 7.0 | 2002 | 5.9 | 2009 | 2.8 |
| 1982 | 45.4 | 1989 | 26.0 | 1996 | 7.2 | 2003 | 4.9 | | |
| 1983 | 43.0 | 1990 | 18.6 | 1997 | 4.7 | 2004 | 3.5 | | |

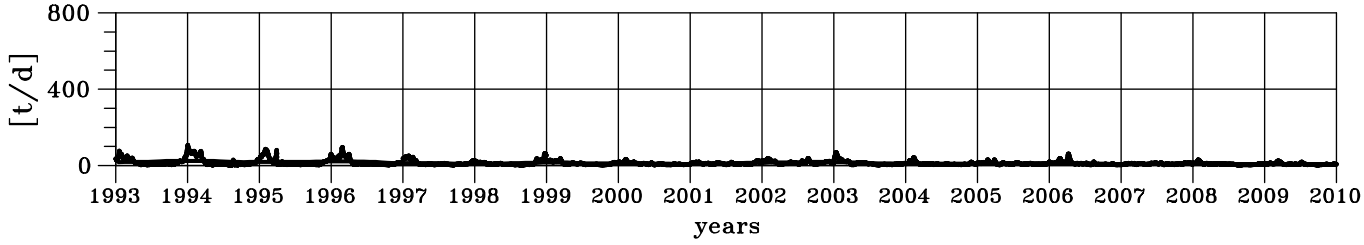
TIME SERIES
mean: 55.8 t/d
relative standard deviation: 1.28
minimum: 0.8 t/d August 8, 1994
maximum: 515.1 t/d January 10, 1987

LOW PASS
minimum: 7.2 t/d August 2008
maximum: 143.8 t/d November 1986

ANNUAL CYCLE
minimum: 19.6 t/d July, rel. stdev: 1.03
maximum: 109.3 t/d February, rel. stdev: 0.92



## Total Phosphorus load for River Elbe

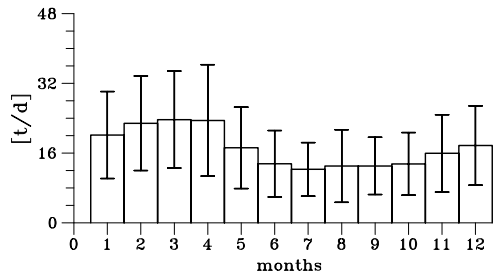
ANNUAL LOADS

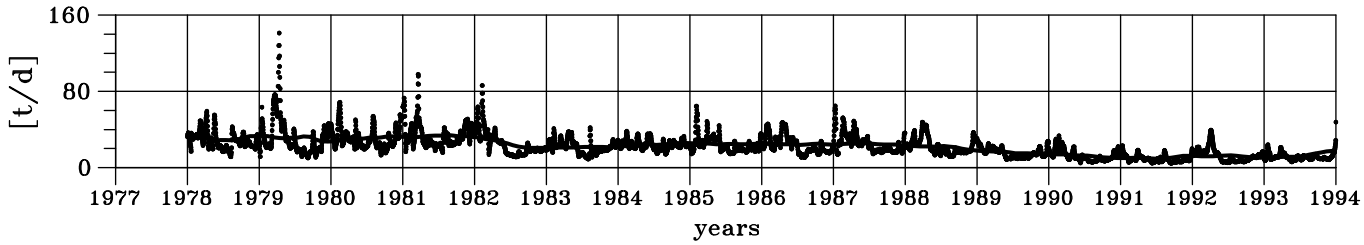
| year | kt/y | year | kt/y | year | kt/y | year | kt/y | year | kt/y |
|---|---|---|---|---|---|---|---|---|---|
| | | 1984 | 8.8 | 1991 | 3.3 | 1998 | 4.6 | 2005 | 4.5 |
| 1978 | 10.5 | 1985 | 8.9 | 1992 | 4.7 | 1999 | 4.6 | 2006 | 3.9 |
| 1979 | 11.6 | 1986 | 8.6 | 1993 | 4.1 | 2000 | 4.3 | 2007 | 3.8 |
| 1980 | 11.3 | 1987 | 9.2 | 1994 | 6.1 | 2001 | 4.7 | 2008 | 3.4 |
| 1981 | 12.2 | 1988 | 8.2 | 1995 | 6.2 | 2002 | 6.8 | 2009 | 3.2 |
| 1982 | 8.9 | 1989 | 5.7 | 1996 | 4.8 | 2003 | 3.6 | | |
| 1983 | 7.9 | 1990 | 4.5 | 1997 | 4.2 | 2004 | 3.5 | | |

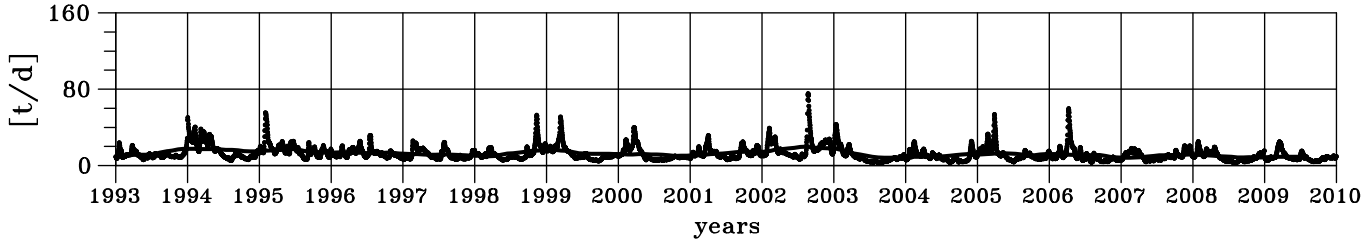
TIME SERIES
mean: 18.3 t/d
relative standard deviation: 3.95
minimum: 2.8 t/d August 3, 2008
maximum: 141.0 t/d April 12, 1979

LOW PASS
minimum: 8.1 t/d October 2003
maximum: 34.0 t/d August 1981

ANNUAL CYCLE
minimum: 12.3 t/d July, rel. stdev: 0.50
maximum: 23.7 t/d March, rel. stdev: 0.47



## Phosphate load for River Elbe

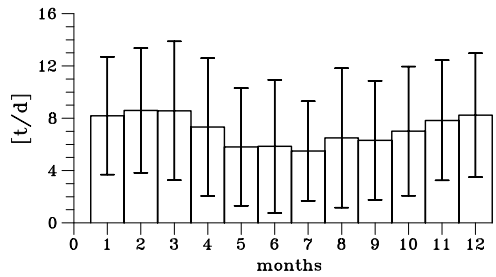
ANNUAL LOADS

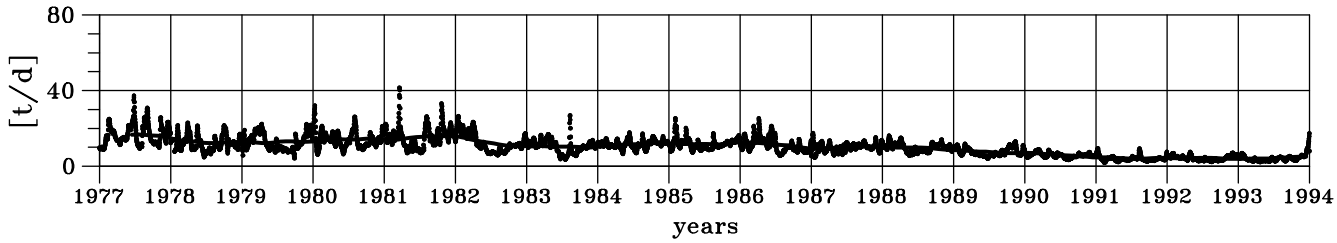
| year | t/y | year | t/y | year | t/y | year | t/y | year | t/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 6046 | 1984 | 4283 | 1991 | 1457 | 1998 | 1450 | 2005 | 1280 |
| 1978 | 4456 | 1985 | 4306 | 1992 | 1598 | 1999 | 1155 | 2006 | 1044 |
| 1979 | 4651 | 1986 | 4147 | 1993 | 1537 | 2000 | 1267 | 2007 | 1322 |
| 1980 | 5152 | 1987 | 3609 | 1994 | 1642 | 2001 | 1503 | 2008 | 967 |
| 1981 | 5649 | 1988 | 3624 | 1995 | 1786 | 2002 | 2828 | 2009 | 949 |
| 1982 | 4501 | 1989 | 2767 | 1996 | 1624 | 2003 | 1277 | | |
| 1983 | 3775 | 1990 | 2120 | 1997 | 1318 | 2004 | 894 | | |

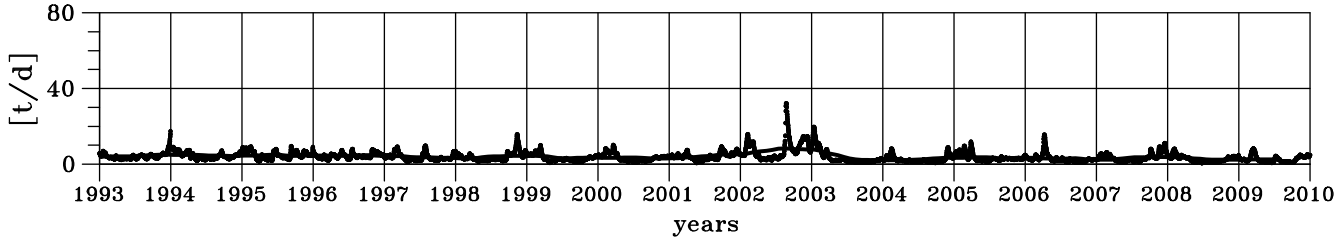
TIME SERIES
mean: 7.1 t/d
relative standard deviation: 0.73
minimum: 0.6 t/d June 25, 2008
maximum: 41.4 t/d March 20, 1981

LOW PASS
minimum: 2.0 t/d January 2004
maximum: 16.7 t/d July 1977

ANNUAL CYCLE
minimum: 5.5 t/d July, rel. stdev: 0.70
maximum: 8.6 t/d February, rel. stdev: 0.55



## Silicate load for River Elbe

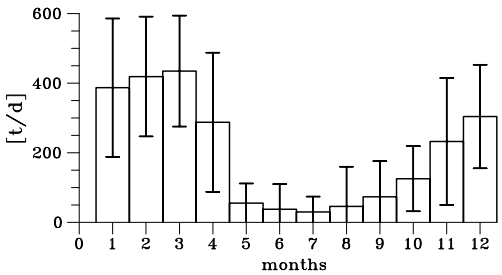
ANNUAL LOADS

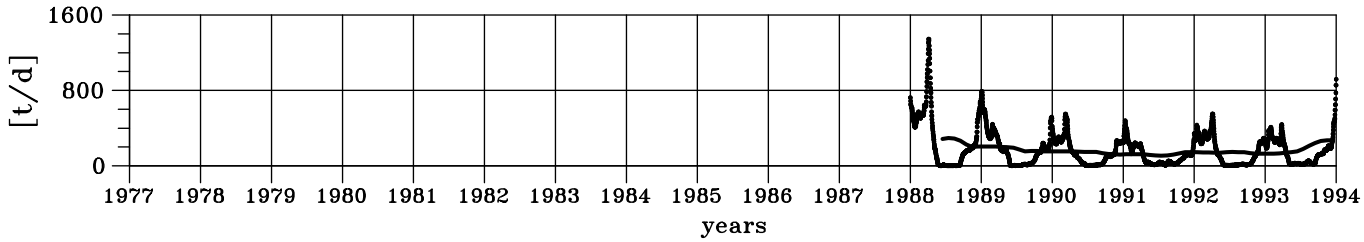
| year | kt/y | year | kt/y | year | kt/y | year | kt/y | year | kt/y |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 1991 | 38.9 | 1998 | 76.3 | 2005 | 72.1 |
| | | | | 1992 | 54.7 | 1999 | 68.1 | 2006 | 74.4 |
| | | | | 1993 | 57.5 | 2000 | 64.3 | 2007 | 80.7 |
| | | | | 1994 | 95.8 | 2001 | 65.7 | 2008 | 68.5 |
| | | 1988 | 106.9 | 1995 | 100.4 | 2002 | 150.2 | 2009 | 62.1 |
| | | 1989 | 66.9 | 1996 | 78.0 | 2003 | 75.2 | | |
| | | 1990 | 53.0 | 1997 | 63.8 | 2004 | 46.8 | | |

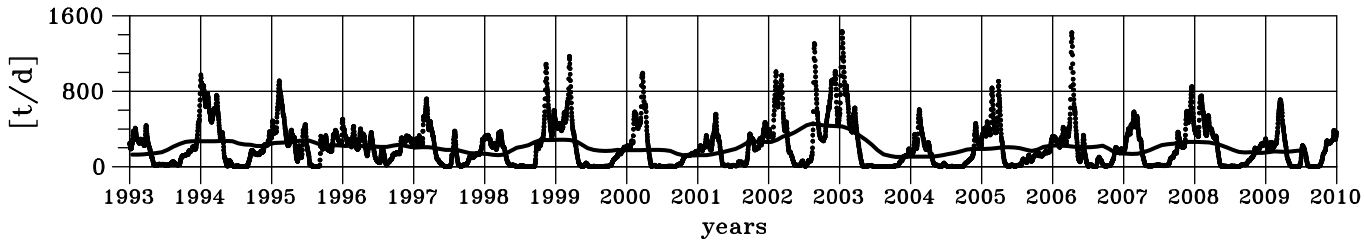
TIME SERIES
mean: 136.8 t/d
relative standard deviation: 1.48
minimum: 0.5 t/d July 3, 2000
maximum: 1435.1 t/d January 13, 2003

LOW PASS
minimum: 104.1 t/d November 2003
maximum: 459.9 t/d August 2002

ANNUAL CYCLE
minimum: 29.9 t/d July, rel. stdev: 1.48
maximum: 434.8 t/d March, rel. stdev: 0.37



## Total Alkalinity load for River Elbe

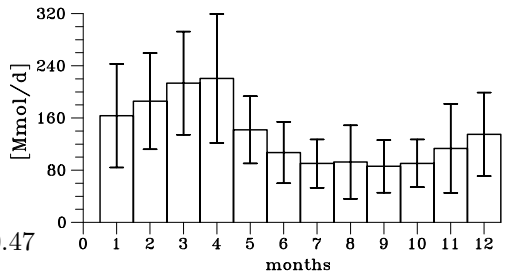
ANNUAL LOADS

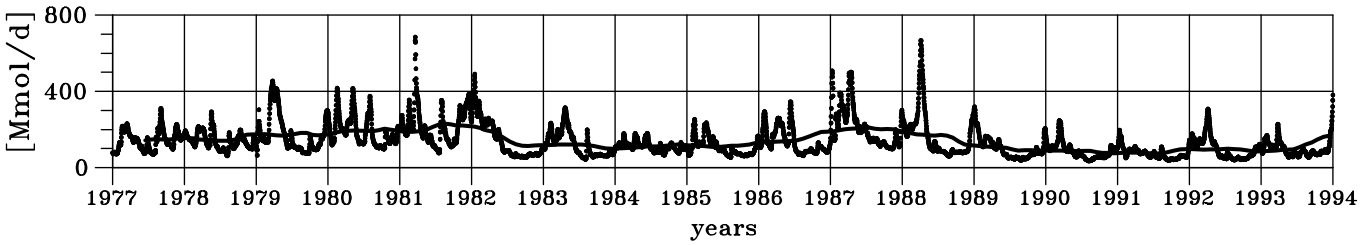
| year | Gmol/y | year | Gmol/y | year | Gmol/y | year | Gmol/y | year | Gmol/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 52.2 | 1984 | 41.1 | 1991 | 26.9 | 1998 | 45.7 | 2005 | 47.1 |
| 1978 | 51.3 | 1985 | 39.2 | 1992 | 36.4 | 1999 | 47.4 | 2006 | 49.7 |
| 1979 | 63.9 | 1986 | 50.4 | 1993 | 35.9 | 2000 | 45.8 | 2007 | 49.1 |
| 1980 | 70.1 | 1987 | 77.1 | 1994 | 60.5 | 2001 | 42.5 | 2008 | 45.4 |
| 1981 | 79.7 | 1988 | 61.8 | 1995 | 63.9 | 2002 | 80.0 | 2009 | 44.8 |
| 1982 | 52.8 | 1989 | 36.6 | 1996 | 47.2 | 2003 | 44.2 | | |
| 1983 | 43.8 | 1990 | 31.4 | 1997 | 42.8 | 2004 | 36.1 | | |

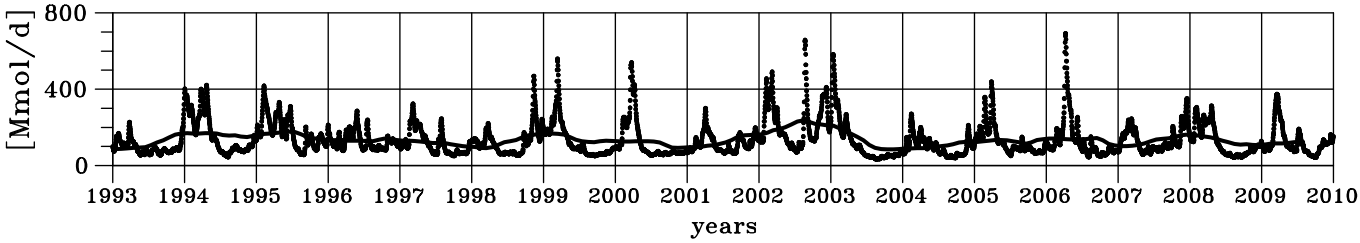
TIME SERIES
mean: 136.3 Mmol/d
relative standard deviation: 0.64
minimum: 33.3 Mmol/d August 18, 2003
maximum: 692.0 Mmold April 9, 2006

LOW PASS
minimum: 73.5 Mmol/d July 1991
maximum: 237.0 Mmol/d August 2002

ANNUAL CYCLE
minimum: 85.9 Mmol/d September, rel. stdev: 0.47
maximum: 220.5 Mmol/d April, rel. stdev: 0.45



## Dissolved Inorganic Carbon load for River Elbe

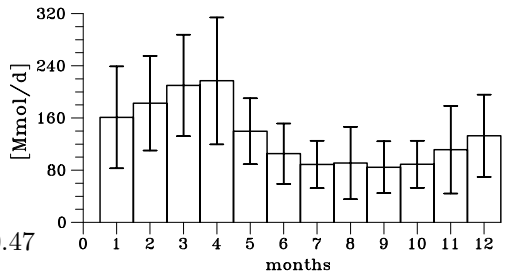
ANNUAL LOADS

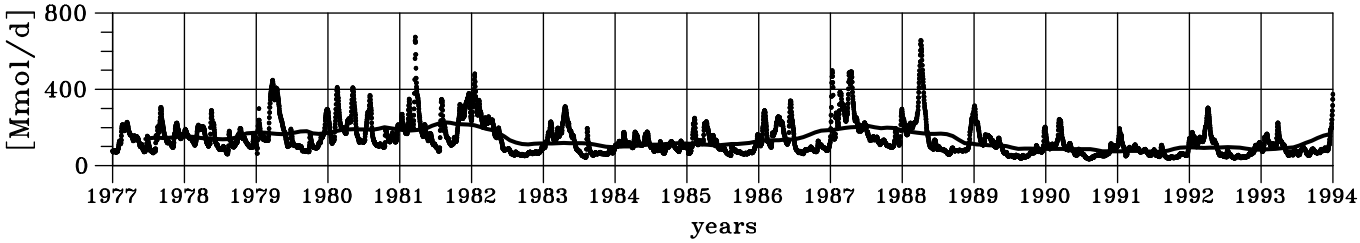
| year | Gmol/y | year | Gmol/y | year | Gmol/y | year | Gmol/y | year | Gmol/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 51.4 | 1984 | 40.4 | 1991 | 26.4 | 1998 | 44.9 | 2005 | 46.4 |
| 1978 | 50.4 | 1985 | 38.6 | 1992 | 35.8 | 1999 | 46.6 | 2006 | 48.9 |
| 1979 | 62.9 | 1986 | 49.5 | 1993 | 35.3 | 2000 | 45.1 | 2007 | 48.3 |
| 1980 | 68.9 | 1987 | 75.8 | 1994 | 59.6 | 2001 | 41.8 | 2008 | 44.7 |
| 1981 | 78.4 | 1988 | 60.8 | 1995 | 62.9 | 2002 | 78.7 | 2009 | 44.0 |
| 1982 | 52.0 | 1989 | 36.0 | 1996 | 46.5 | 2003 | 43.5 | | |
| 1983 | 43.1 | 1990 | 30.9 | 1997 | 42.1 | 2004 | 35.5 | | |

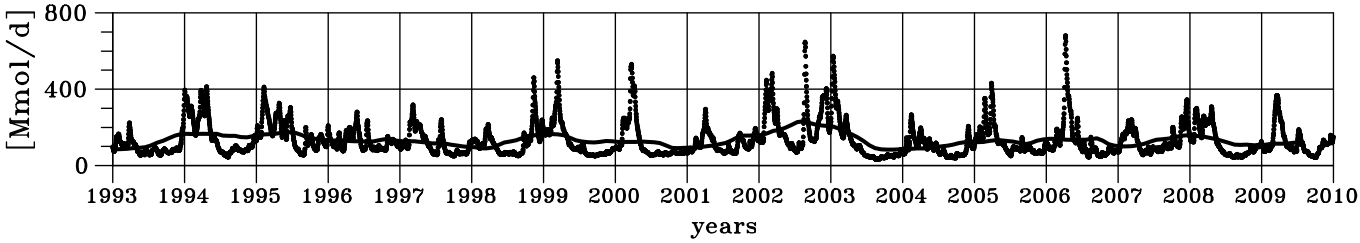
TIME SERIES
mean: 134.1 Mmol/d
relative standard deviation: 0.64
minimum: 32.8 Mmol/d August 18, 2003
maximum: 680.8 Mmold April 9, 2006

LOW PASS
minimum: 72.3 Mmol/d July 1991
maximum: 233.1 Mmol/d August 2002

ANNUAL CYCLE
minimum: 84.5 Mmol/d September, rel. stdev: 0.47
maximum: 216.9 Mmol/d April, rel. stdev: 0.45



## Dissolved Organic Carbon load for River Elbe

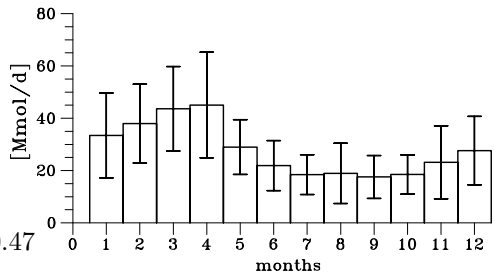
ANNUAL LOADS

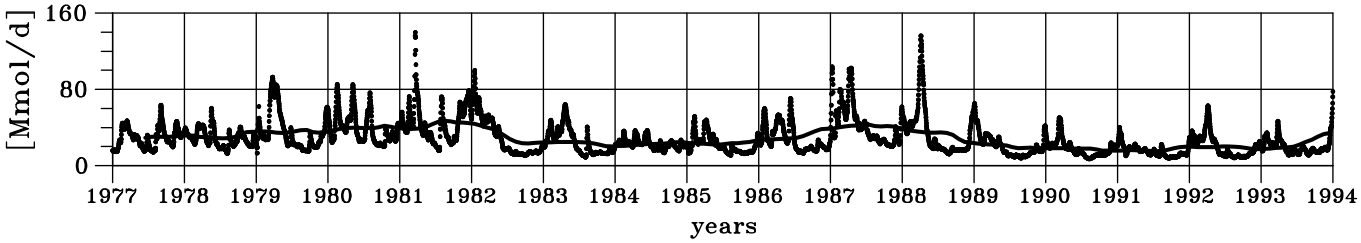
| year | Gmol/y | year | Gmol/y | year | Gmol/y | year | Gmol/y | year | Gmol/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 10.7 | 1984 | 8.4 | 1991 | 5.5 | 1998 | 9.3 | 2005 | 9.6 |
| 1978 | 10.5 | 1985 | 8.0 | 1992 | 7.4 | 1999 | 9.7 | 2006 | 10.2 |
| 1979 | 13.1 | 1986 | 10.3 | 1993 | 7.3 | 2000 | 9.4 | 2007 | 10.0 |
| 1980 | 14.3 | 1987 | 15.7 | 1994 | 12.4 | 2001 | 8.7 | 2008 | 9.3 |
| 1981 | 16.3 | 1988 | 12.6 | 1995 | 13.1 | 2002 | 16.3 | 2009 | 9.2 |
| 1982 | 10.8 | 1989 | 7.5 | 1996 | 9.7 | 2003 | 9.0 | | |
| 1983 | 9.0 | 1990 | 6.4 | 1997 | 8.8 | 2004 | 7.4 | | |

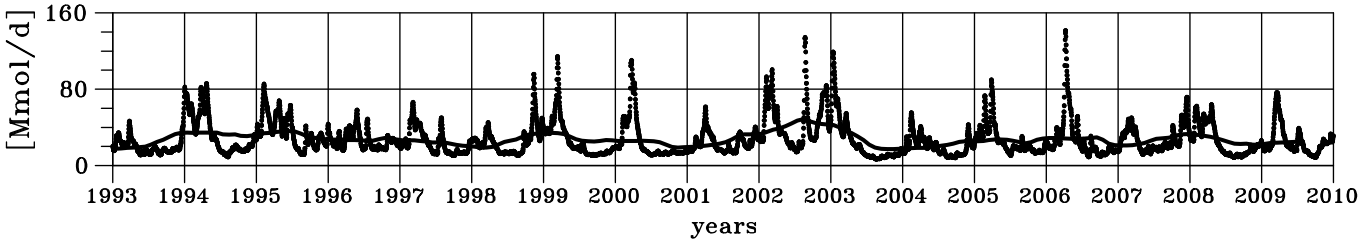
TIME SERIES
mean: 27.9 Mmol/d
relative standard deviation: 0.64
minimum: 6.8 Mmol/d August 18, 2003
maximum: 141.4 Mmold April 9, 2006

LOW PASS
minimum: 15.0 Mmol/d July 1991
maximum: 48.4 Mmol/d August 2002

ANNUAL CYCLE
minimum: 17.5 Mmol/d September, rel. stdev: 0.47
maximum: 45.1 Mmol/d April, rel. stdev: 0.45



## 5.2 Loads of River Weser

### Total Nitrogen load for River Weser

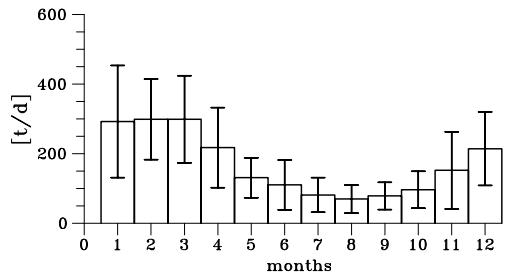
ANNUAL LOADS

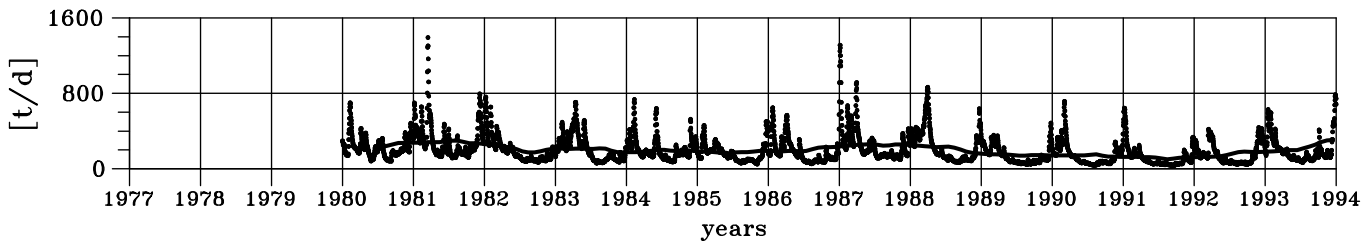
| year | kt/y | year | kt/y | year | kt/y | year | kt/y | year | kt/y |
|---|---|---|---|---|---|---|---|---|---|
| | | 1984 | 75.2 | 1991 | 43.3 | 1998 | 67.8 | 2005 | 40.9 |
| | | 1985 | 59.4 | 1992 | 55.6 | 1999 | 60.2 | 2006 | 32.4 |
| | | 1986 | 64.7 | 1993 | 73.5 | 2000 | 45.9 | 2007 | 60.4 |
| 1980 | 81.5 | 1987 | 96.8 | 1994 | 103.4 | 2001 | 47.1 | 2008 | 46.5 |
| 1981 | 109.2 | 1988 | 87.1 | 1995 | 71.8 | 2002 | 78.4 | 2009 | 33.6 |
| 1982 | 70.1 | 1989 | 50.8 | 1996 | 35.9 | 2003 | 47.4 | | |
| 1983 | 76.2 | 1990 | 50.9 | 1997 | 44.1 | 2004 | 47.7 | | |

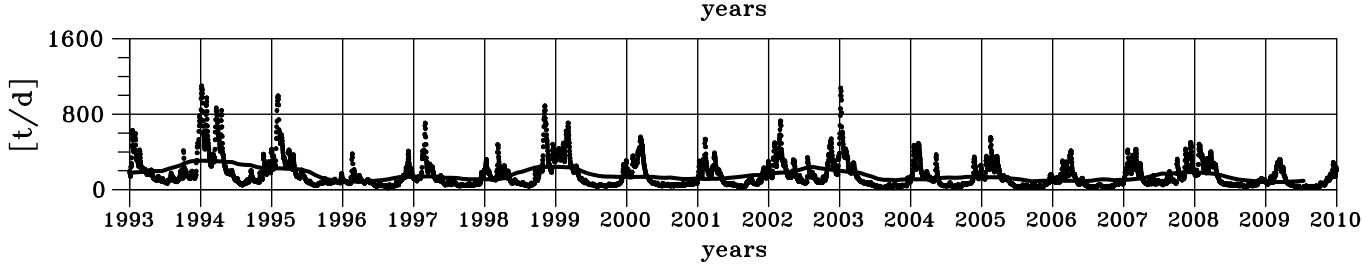
TIME SERIES
mean: 156.6 t/d
relative standard deviation: 0.94
minimum: 17.1 t/d August 21, 1996
maximum: 1392.4 t/d March 16, 1981

LOW PASS
minimum: 80.8 t/d March 2009
maximum: 308.0 t/d January 1994

ANNUAL CYCLE
minimum: 69.8 t/d August, rel. stdev: 0.57
maximum: 298.8 t/d February, rel. stdev: 0.39



## Nitrate load for River Weser

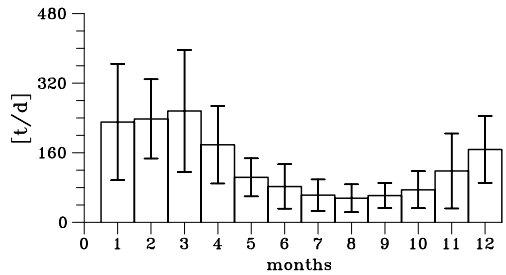
ANNUAL LOADS

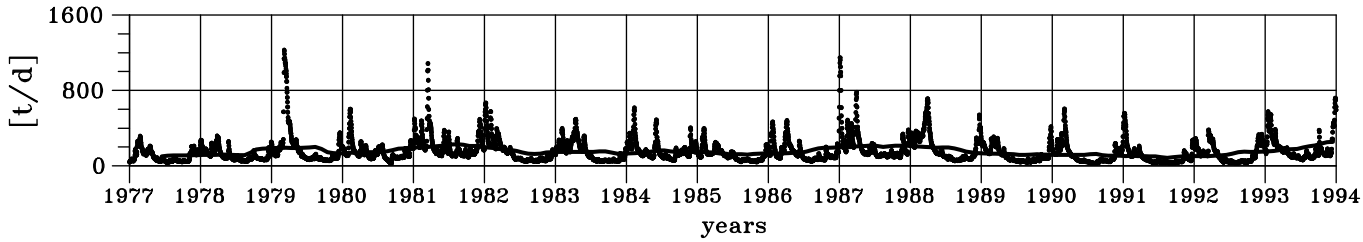
| year | kt/y | year | kt/y | year | kt/y | year | kt/y | year | kt/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 36.7 | 1984 | 60.1 | 1991 | 35.8 | 1998 | 57.0 | 2005 | 27.1 |
| 1978 | 41.6 | 1985 | 42.2 | 1992 | 44.9 | 1999 | 45.1 | 2006 | 27.7 |
| 1979 | 70.9 | 1986 | 51.1 | 1993 | 67.2 | 2000 | 38.1 | 2007 | 53.4 |
| 1980 | 52.0 | 1987 | 79.8 | 1994 | 81.3 | 2001 | 36.1 | 2008 | 40.6 |
| 1981 | 80.9 | 1988 | 72.1 | 1995 | 59.7 | 2002 | 61.4 | 2009 | 27.0 |
| 1982 | 54.2 | 1989 | 42.6 | 1996 | 29.3 | 2003 | 41.6 | | |
| 1983 | 53.1 | 1990 | 41.5 | 1997 | 36.3 | 2004 | 42.1 | | |

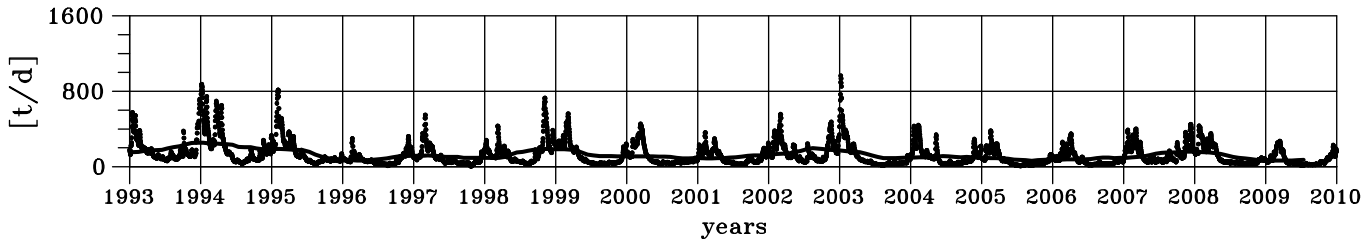
TIME SERIES
mean: 135.3 t/d
relative standard deviation: 0.91
minimum: 3.7 t/d October 23, 1997
maximum: 1227.0 t/d March 7, 1979

LOW PASS
minimum: 64.3 t/d September 2005
maximum: 253.3 t/d December 1993

ANNUAL CYCLE
minimum: 55.5 t/d August, rel. stdev: 0.57
maximum: 256.0 t/d March, rel. stdev: 0.55



## Ammonium load for River Weser

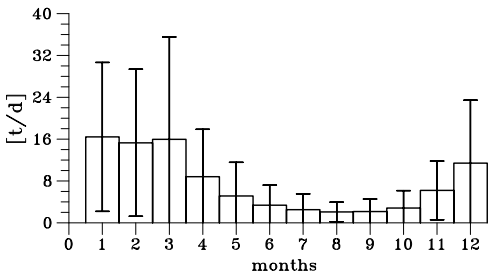
ANNUAL LOADS

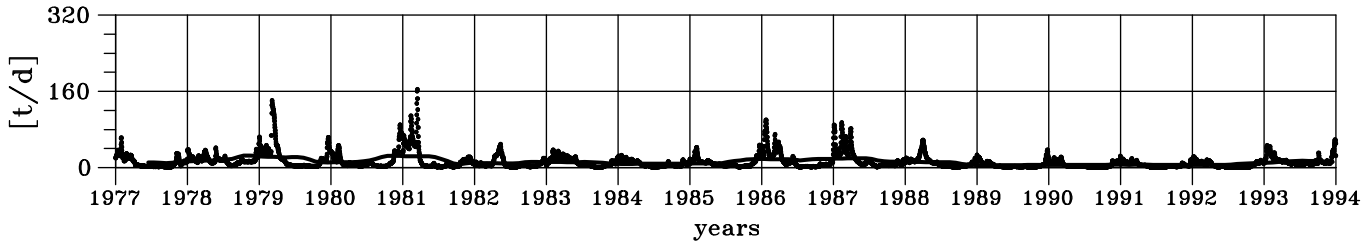
| year | t/y | year | t/y | year | t/y | year | t/y | year | t/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 3882 | 1984 | 2882 | 1991 | 2036 | 1998 | 1556 | 2005 | 722 |
| 1978 | 5909 | 1985 | 3781 | 1992 | 2145 | 1999 | 1448 | 2006 | 656 |
| 1979 | 8198 | 1986 | 5796 | 1993 | 5457 | 2000 | 824 | 2007 | 950 |
| 1980 | 5117 | 1987 | 6997 | 1994 | 2378 | 2001 | 1048 | 2008 | 654 |
| 1981 | 7208 | 1988 | 4097 | 1995 | 868 | 2002 | 1065 | 2009 | 634 |
| 1982 | 3104 | 1989 | 1980 | 1996 | 1599 | 2003 | 974 | | |
| 1983 | 4198 | 1990 | 2028 | 1997 | 1251 | 2004 | 778 | | |

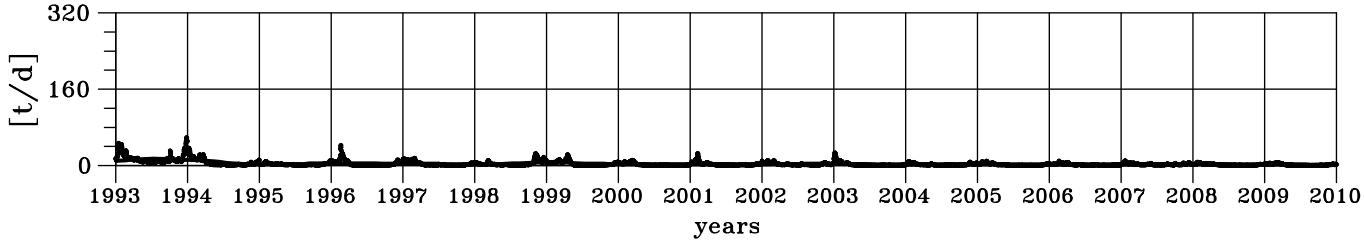
TIME SERIES
mean: 7.7 t/d
relative standard deviation: 1.59
minimum: 0.2 t/d July 2, 1992
maximum: 163.8 t/d March 16, 1981

LOW PASS
minimum: 1.5 t/d October 2003
maximum: 24.9 t/d November 1978

ANNUAL CYCLE
minimum: 2.1 t/d August, rel. stdev: 0.90
maximum: 16.4 t/d January, rel. stdev: 0.87



## Total Phosphorus load for River Weser

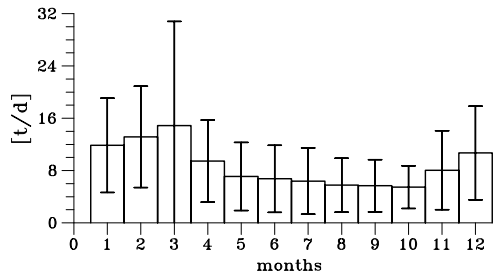
ANNUAL LOADS

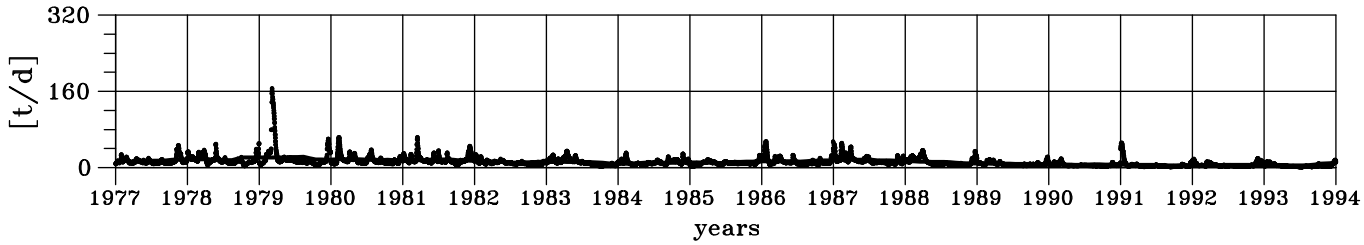
| year | kt/y | year | kt/y | year | kt/y | year | kt/y | year | kt/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 5.0 | 1984 | 4.0 | 1991 | 2.1 | 1998 | 2.4 | 2005 | 1.8 |
| 1978 | 6.0 | 1985 | 3.5 | 1992 | 2.2 | 1999 | 2.3 | 2006 | 1.5 |
| 1979 | 8.1 | 1986 | 4.8 | 1993 | 1.5 | 2000 | 1.7 | 2007 | 2.4 |
| 1980 | 5.8 | 1987 | 6.0 | 1994 | 3.6 | 2001 | 2.0 | 2008 | 1.8 |
| 1981 | 6.3 | 1988 | 4.5 | 1995 | 3.0 | 2002 | 2.5 | 2009 | 1.4 |
| 1982 | 3.8 | 1989 | 2.8 | 1996 | 1.4 | 2003 | 1.5 | | |
| 1983 | 4.2 | 1990 | 2.0 | 1997 | 1.8 | 2004 | 1.9 | | |

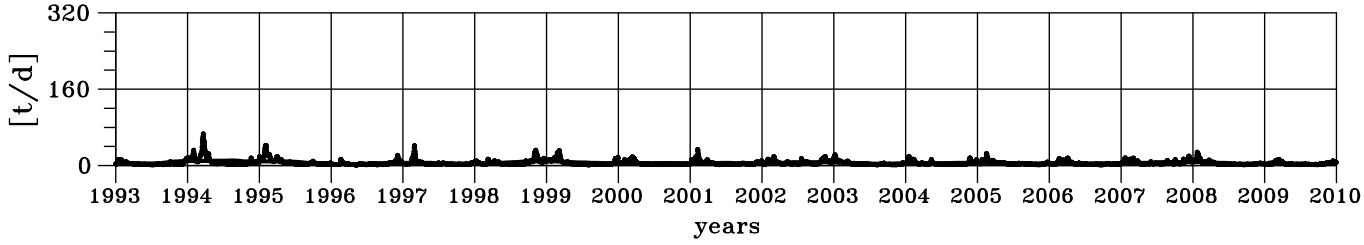
TIME SERIES
mean: 8.7 t/d
relative standard deviation: 1.01
minimum: 0.7 t/d May 8, 1996
maximum: 165.7 t/d March 7, 1979

LOW PASS
minimum: 3.0 t/d April 1996
maximum: 22.4 t/d August 1979

ANNUAL CYCLE
minimum: 5.5 t/d October, rel. stdev: 0.60
maximum: 14.9 t/d March, rel. stdev: 1.07



## Phosphate load for River Weser

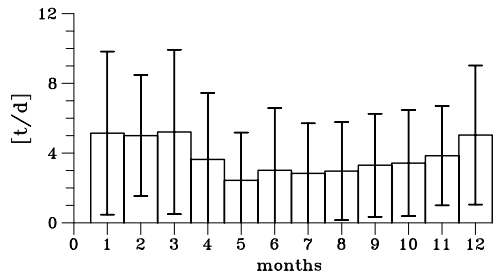
ANNUAL LOADS

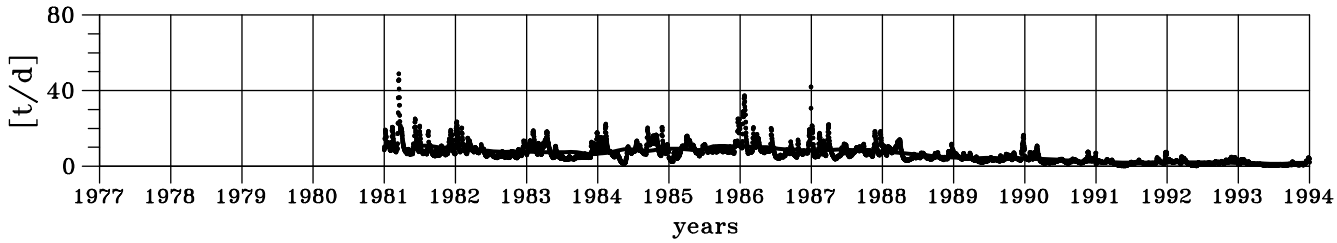
| year | t/y | year | t/y | year | t/y | year | t/y | year | t/y |
|---|---|---|---|---|---|---|---|---|---|
| | | 1984 | 3259 | 1991 | 670 | 1998 | 1069 | 2005 | 569 |
| | | 1985 | 3260 | 1992 | 774 | 1999 | 656 | 2006 | 494 |
| | | 1986 | 3541 | 1993 | 420 | 2000 | 694 | 2007 | 848 |
| | | 1987 | 3165 | 1994 | 774 | 2001 | 715 | 2008 | 317 |
| 1981 | 3953 | 1988 | 2240 | 1995 | 711 | 2002 | 1112 | 2009 | 383 |
| 1982 | 2914 | 1989 | 1597 | 1996 | 595 | 2003 | 539 | | |
| 1983 | 2691 | 1990 | 1176 | 1997 | 682 | 2004 | 596 | | |

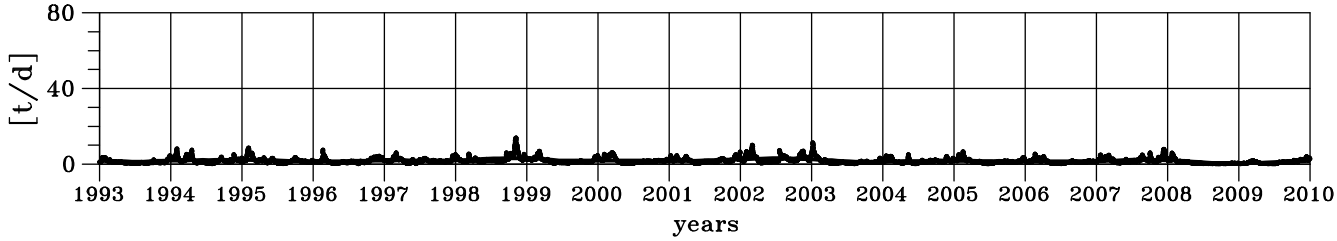
TIME SERIES
mean: 4.4 t/d
relative standard deviation: 2.21
minimum: 0.2 t/d August 21, 1996
maximum: 48.9 t/d March 16, 1981

LOW PASS
minimum: 0.5 t/d December 2008
maximum: 10.9 t/d July 1981

ANNUAL CYCLE
minimum: 2.4 t/d May, rel. stdev: 1.13
maximum: 5.2 t/d March, rel. stdev: 0.91



## Silicate load for River Weser

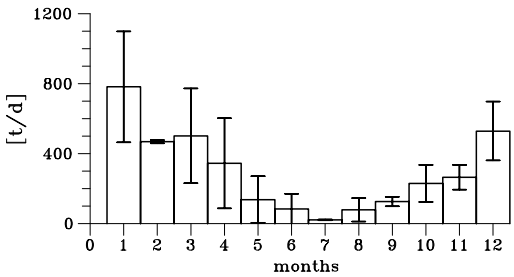
ANNUAL LOADS

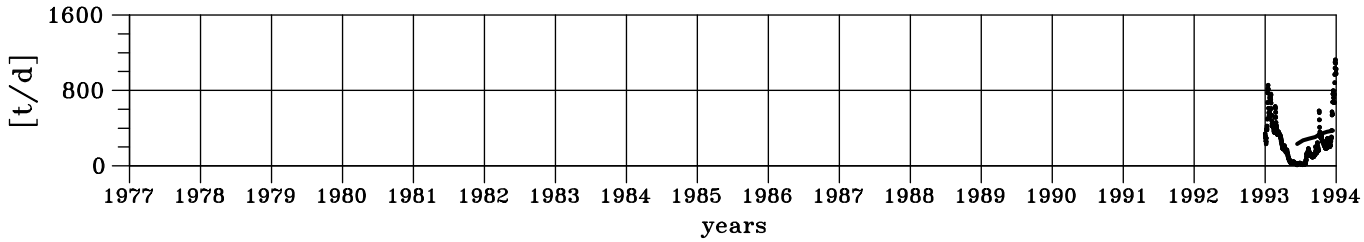
| year | kt/y | year | kt/y | year | kt/y | year | kt/y | year | kt/y |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | 1993 | 91.6 | | | | |
| | | | | 1994 | 125.0 | | | | |
| | | | | | | | | | |
| | | | | | | | | | |
| | | | | | | | | | |

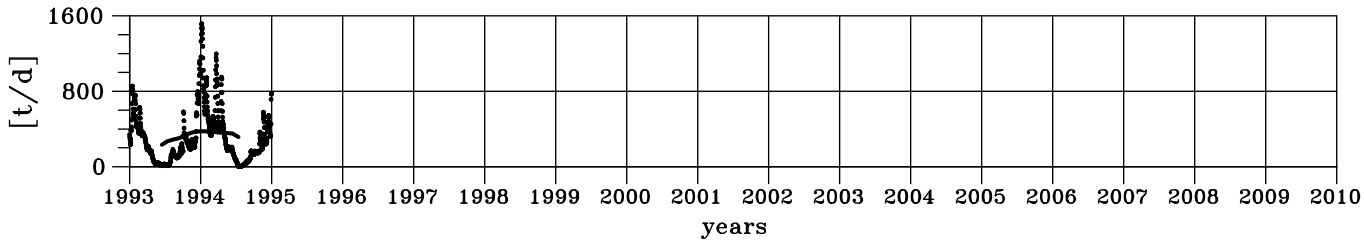
TIME SERIES
mean: 36.9 t/d
relative standard deviation: 3.59
minimum: 1.7 t/d July 14, 1994
maximum: 1514.5 t/d January 7, 1994

LOW PASS
minimum: 234.3 t/d June 1993
maximum: 378.1 t/d January 1994

ANNUAL CYCLE
minimum: 21.1 t/d July, rel. stdev: 0.12
maximum: 782.1 t/d January, rel. stdev: 0.41



## 5.3 Loads of River Ems

### Total Nitrogen load for River Ems

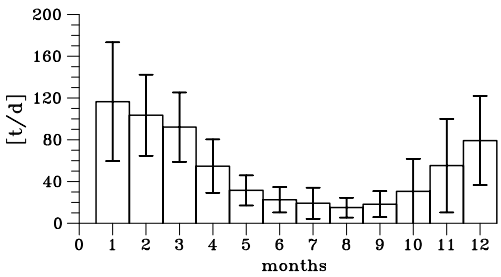
ANNUAL LOADS

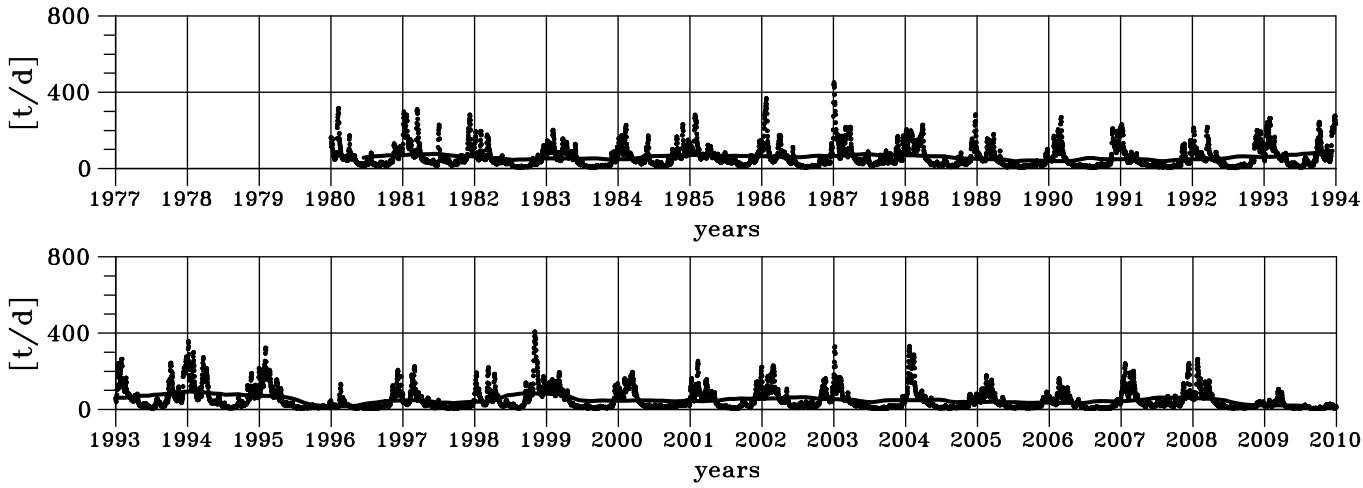
| year | kt/y | year | kt/y | year | kt/y | year | kt/y | year | kt/y |
|---|---|---|---|---|---|---|---|---|---|
| | | 1984 | 24.0 | 1991 | 14.9 | 1998 | 28.3 | 2005 | 14.2 |
| | | 1985 | 22.9 | 1992 | 20.5 | 1999 | 17.1 | 2006 | 11.6 |
| | | 1986 | 21.4 | 1993 | 27.5 | 2000 | 16.2 | 2007 | 22.9 |
| 1980 | 20.8 | 1987 | 28.2 | 1994 | 28.5 | 2001 | 19.5 | 2008 | 15.5 |
| 1981 | 29.3 | 1988 | 24.9 | 1995 | 19.6 | 2002 | 22.1 | 2009 | 6.9 |
| 1982 | 16.5 | 1989 | 13.8 | 1996 | 11.8 | 2003 | 13.7 | | |
| 1983 | 18.5 | 1990 | 18.8 | 1997 | 12.0 | 2004 | 18.9 | | |

TIME SERIES
mean: 51.5 t/d
relative standard deviation: 2.16
minimum: 3.6 t/d September 7, 2003
maximum: 451.0 t/d January 4, 1987

LOW PASS
minimum: 17.1 t/d February 1996
maximum: 93.2 t/d January 1994

ANNUAL CYCLE
minimum: 15.0 t/d August, rel. stdev: 0.64
maximum: 116.5 t/d January, rel. stdev: 0.49



## Nitrate load for River Ems

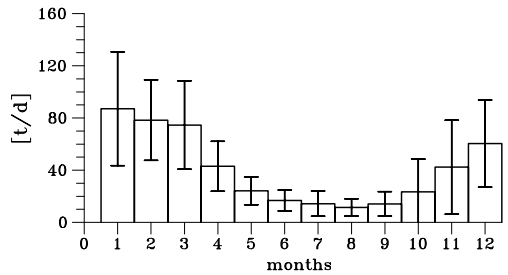
ANNUAL LOADS

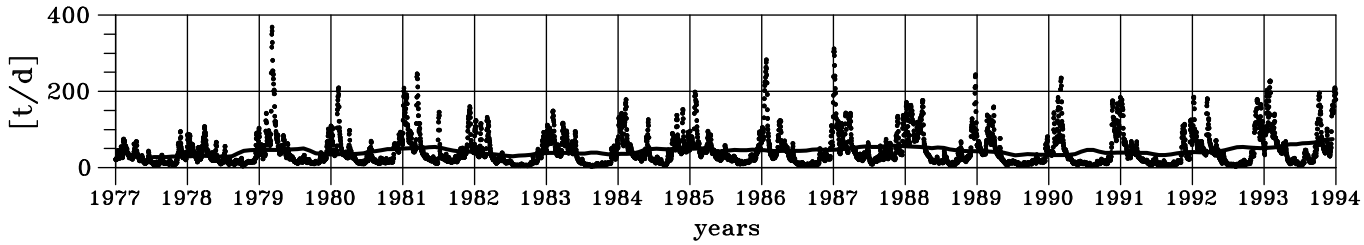
| year | kt/y | year | kt/y | year | kt/y | year | kt/y | year | kt/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 9.4 | 1984 | 18.0 | 1991 | 12.1 | 1998 | 23.1 | 2005 | 11.8 |
| 1978 | 10.7 | 1985 | 15.0 | 1992 | 17.4 | 1999 | 13.5 | 2006 | 9.6 |
| 1979 | 17.6 | 1986 | 16.0 | 1993 | 22.5 | 2000 | 12.9 | 2007 | 19.8 |
| 1980 | 13.9 | 1987 | 20.5 | 1994 | 23.3 | 2001 | 15.9 | 2008 | 12.3 |
| 1981 | 20.2 | 1988 | 20.1 | 1995 | 15.4 | 2002 | 17.5 | 2009 | 5.9 |
| 1982 | 10.6 | 1989 | 11.7 | 1996 | 9.4 | 2003 | 10.6 | | |
| 1983 | 13.2 | 1990 | 16.0 | 1997 | 9.8 | 2004 | 14.5 | | |

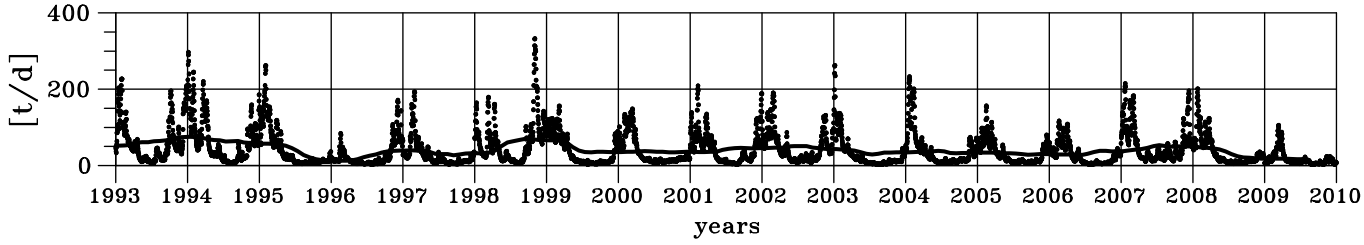
TIME SERIES
mean: 40.7 t/d
relative standard deviation: 1.06
minimum: 2.3 t/d July 30, 1999
maximum: 368.5 t/d March 8, 1979

LOW PASS
minimum: 12.6 t/d February 1996
maximum: 75.4 t/d January 1994

ANNUAL CYCLE
minimum: 11.4 t/d August, rel. stdev: 0.58
maximum: 87.1 t/d January, rel. stdev: 0.50



## Ammonium load for River Ems

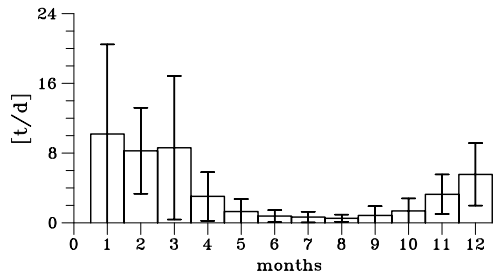
ANNUAL LOADS

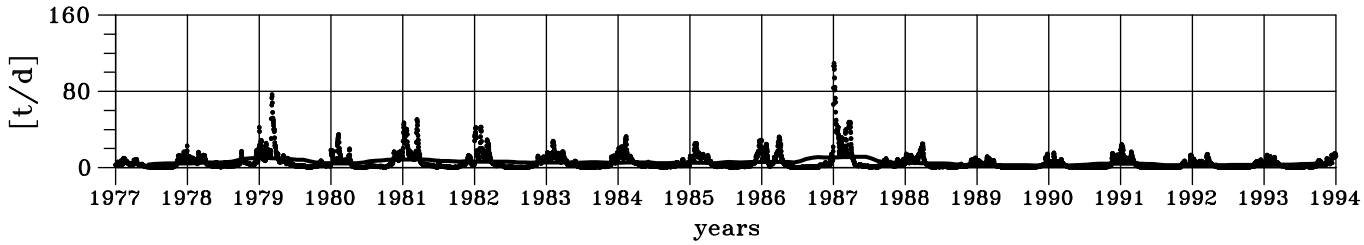
| year | t/y | year | t/y | year | t/y | year | t/y | year | t/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 1294 | 1984 | 1814 | 1991 | 1267 | 1998 | 1098 | 2005 | 516 |
| 1978 | 1886 | 1985 | 2175 | 1992 | 935 | 1999 | 722 | 2006 | 519 |
| 1979 | 3122 | 1986 | 1824 | 1993 | 1340 | 2000 | 619 | 2007 | 1088 |
| 1980 | 2057 | 1987 | 4090 | 1994 | 1326 | 2001 | 659 | 2008 | 565 |
| 1981 | 2714 | 1988 | 1624 | 1995 | 996 | 2002 | 870 | 2009 | 473 |
| 1982 | 2308 | 1989 | 866 | 1996 | 695 | 2003 | 694 | | |
| 1983 | 1868 | 1990 | 1034 | 1997 | 607 | 2004 | 718 | | |

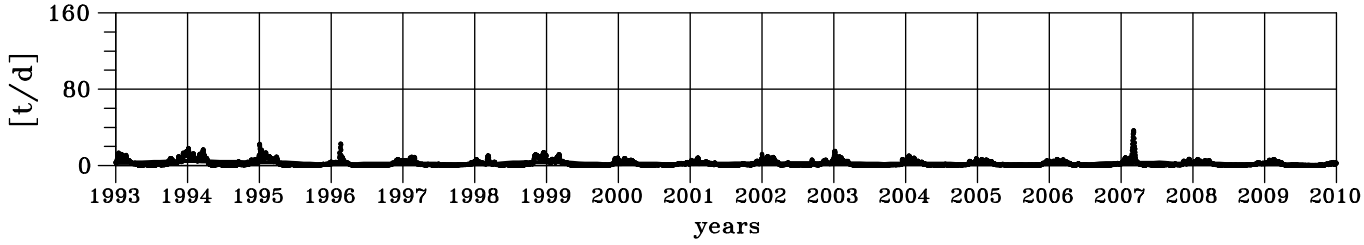
TIME SERIES
mean: 3.7 t/d
relative standard deviation: 1.70
minimum: 0.1 t/d August 5, 1990
maximum: 109.2 t/d January 4, 1987

LOW PASS
minimum: 1.2 t/d July 2009
maximum: 11.4 t/d May 1987

ANNUAL CYCLE
minimum: 0.5 t/d August, rel. stdev: 0.78
maximum: 10.2 t/d January, rel. stdev: 1.01



## Total Phosphorus load for River Ems

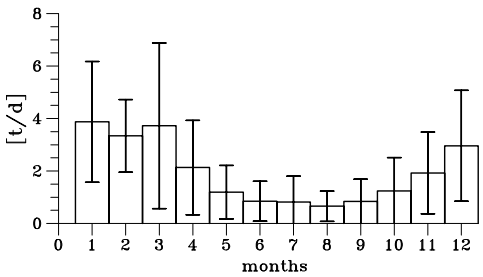
ANNUAL LOADS

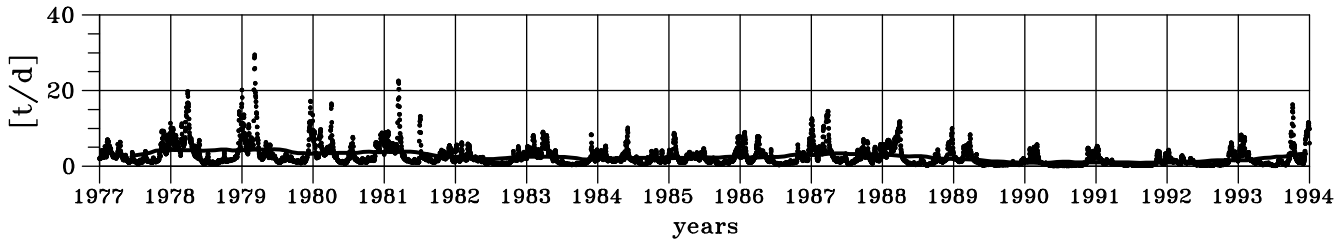
| year | t/y | year | t/y | year | t/y | year | t/y | year | t/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 1028 | 1984 | 762 | 1991 | 353 | 1998 | 851 | 2005 | 365 |
| 1978 | 1495 | 1985 | 827 | 1992 | 439 | 1999 | 539 | 2006 | 276 |
| 1979 | 1653 | 1986 | 870 | 1993 | 895 | 2000 | 397 | 2007 | 738 |
| 1980 | 1257 | 1987 | 1214 | 1994 | 929 | 2001 | 520 | 2008 | 457 |
| 1981 | 1285 | 1988 | 1019 | 1995 | 637 | 2002 | 546 | 2009 | 385 |
| 1982 | 675 | 1989 | 459 | 1996 | 336 | 2003 | 389 | | |
| 1983 | 880 | 1990 | 410 | 1997 | 268 | 2004 | 434 | | |

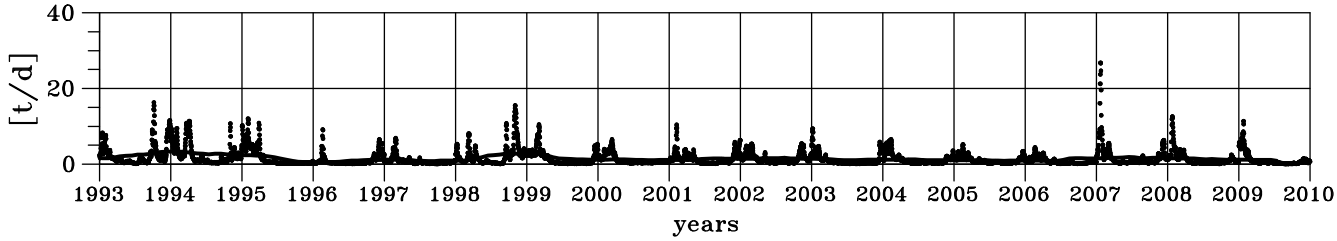
TIME SERIES
mean: 2.0 t/d
relative standard deviation: 1.25
minimum: 0.1 t/d September 29, 1997
maximum: 29.4 t/d March 8, 1979

LOW PASS
minimum: 0.5 t/d January 1996
maximum: 4.4 t/d June 1979

ANNUAL CYCLE
minimum: 0.7 t/d August, rel. stdev: 0.88
maximum: 3.9 t/d January, rel. stdev: 0.59



## Phosphate load for River Ems

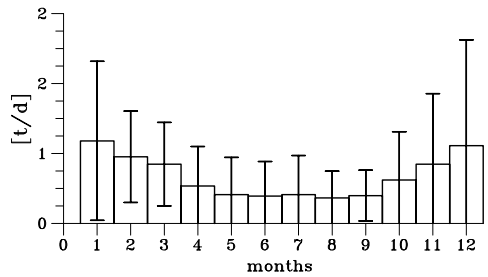
ANNUAL LOADS

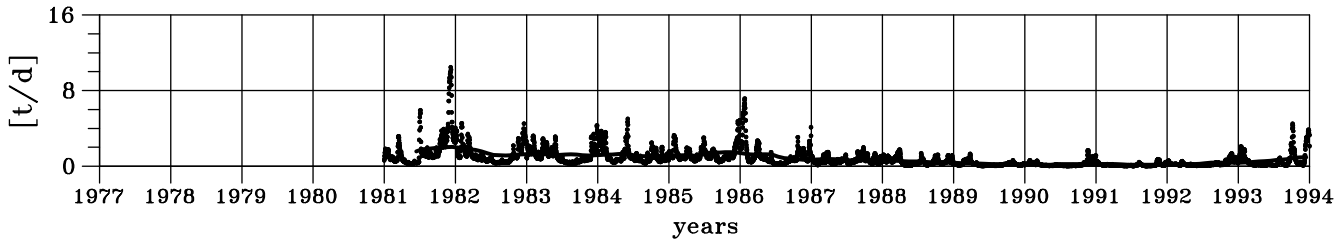
| year | t/y | year | t/y | year | t/y | year | t/y | year | t/y |
|---|---|---|---|---|---|---|---|---|---|
| | | 1984 | 430 | 1991 | 52 | 1998 | 200 | 2005 | 83 |
| | | 1985 | 466 | 1992 | 101 | 1999 | 96 | 2006 | 68 |
| | | 1986 | 421 | 1993 | 238 | 2000 | 90 | 2007 | 168 |
| | | 1987 | 225 | 1994 | 237 | 2001 | 95 | 2008 | 134 |
| 1981 | 642 | 1988 | 190 | 1995 | 149 | 2002 | 136 | 2009 | 93 |
| 1982 | 446 | 1989 | 78 | 1996 | 69 | 2003 | 115 | | |
| 1983 | 428 | 1990 | 84 | 1997 | 65 | 2004 | 93 | | |

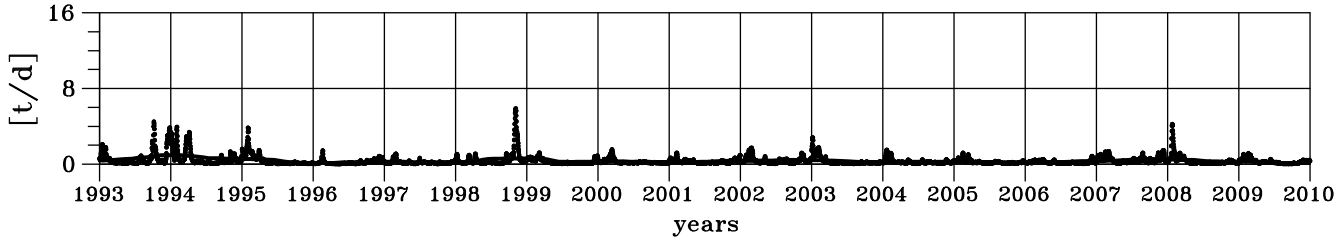
TIME SERIES
mean: 0.7 t/d
relative standard deviation: 3.65
minimum: 0.0 t/d September 15, 1991
maximum: 10.5 t/d December 8, 1981

LOW PASS
minimum: 0.1 t/d January 1996
maximum: 2.0 t/d December 1981

ANNUAL CYCLE
minimum: 0.3 t/d August, rel. stdev: 1.06
maximum: 0.9 t/d January, rel. stdev: 0.96



## Silicate load for River Ems

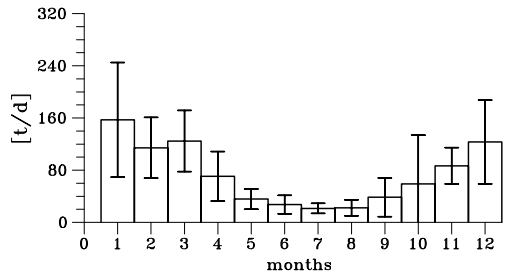
ANNUAL LOADS

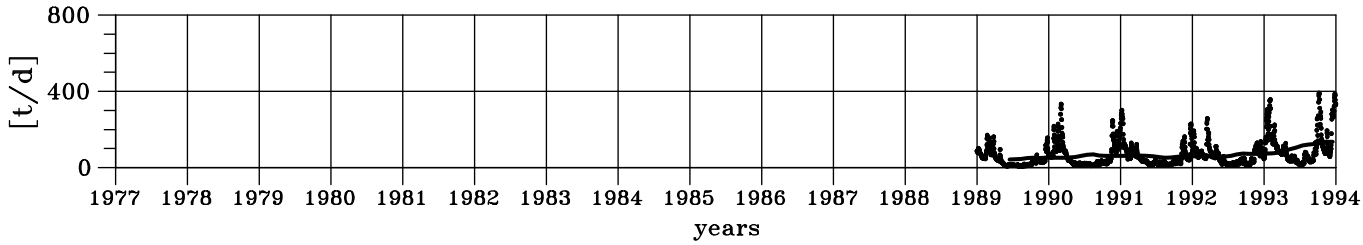
| year | kt/y | year | kt/y | year | kt/y | year | kt/y | year | kt/y |
|---|---|---|---|---|---|---|---|---|---|
| | | | | 1991 | 21.4 | | | | |
| | | | | 1992 | 21.0 | | | | |
| | | | | 1993 | 40.9 | | | | |
| | | | | 1994 | 38.8 | | | | |
| | | | | | | | | | |
| | | 1989 | 15.6 | | | | | | |
| | | 1990 | 22.8 | | | | | | |

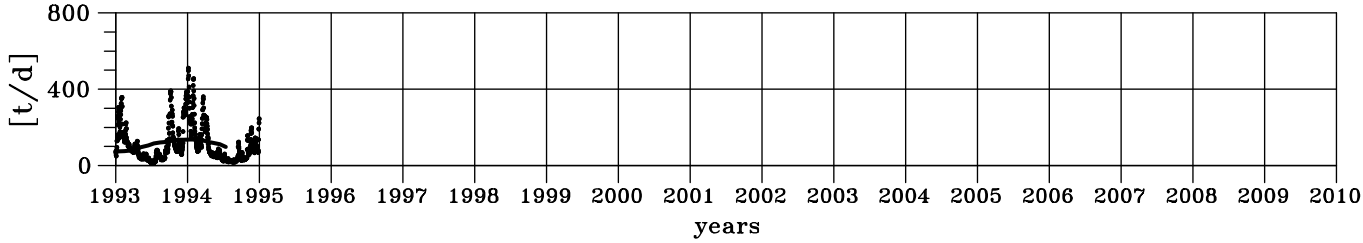
TIME SERIES
mean: 24.9 t/d
relative standard deviation: 2.21
minimum: 6.0 t/d June 4, 1989
maximum: 510.2 t/d January 5, 1994

LOW PASS
minimum: 41.7 t/d June 1989
maximum: 136.5 t/d January 1994

ANNUAL CYCLE
minimum: 21.5 t/d July, rel. stdev: 0.35
maximum: 157.1 t/d January, rel. stdev: 0.56



## Total Alkalinity load for River Ems

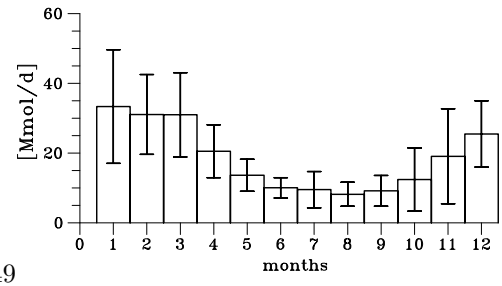
ANNUAL LOADS

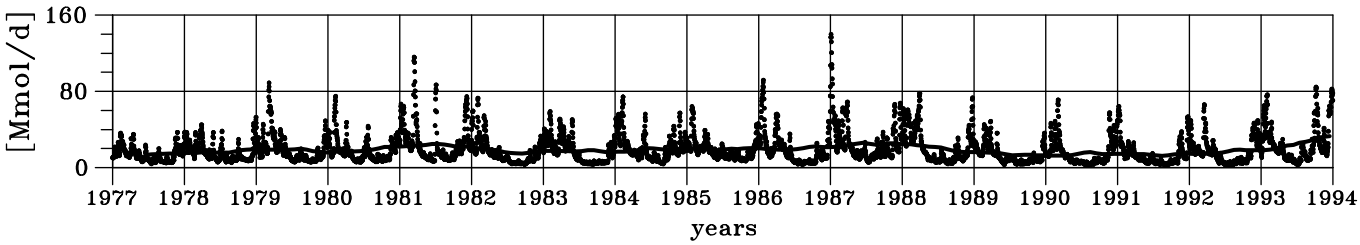
| year | Gmol/y | year | Gmol/y | year | Gmol/y | year | Gmol/y | year | Gmol/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 4.9 | 1984 | 7.5 | 1991 | 4.9 | 1998 | 9.6 | 2005 | 5.9 |
| 1978 | 5.8 | 1985 | 6.6 | 1992 | 5.9 | 1999 | 7.0 | 2006 | 5.0 |
| 1979 | 7.0 | 1986 | 6.8 | 1993 | 9.0 | 2000 | 6.8 | 2007 | 8.5 |
| 1980 | 6.3 | 1987 | 9.6 | 1994 | 10.6 | 2001 | 6.8 | 2008 | 6.5 |
| 1981 | 9.3 | 1988 | 8.0 | 1995 | 8.0 | 2002 | 8.8 | 2009 | 5.1 |
| 1982 | 5.6 | 1989 | 4.7 | 1996 | 3.9 | 2003 | 6.2 | | |
| 1983 | 6.1 | 1990 | 5.4 | 1997 | 4.6 | 2004 | 6.9 | | |

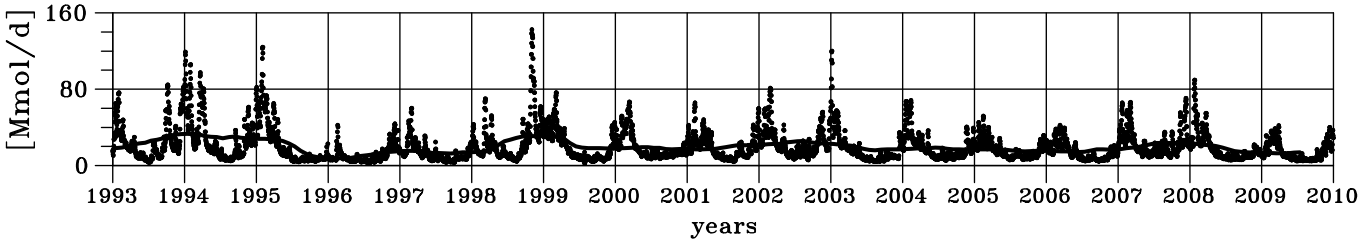
TIME SERIES
mean: 18.6 Mmol/d
relative standard deviation: 0.85
minimum: 2.4 Mmol/d July 30, 1999
maximum: 142.3 Mmold November 3, 1998

LOW PASS
minimum: 7.5 Mmol/d March 1996
maximum: 33.3 Mmol/d January 1994

ANNUAL CYCLE
minimum: 8.2 Mmol/d August, rel. stdev: 0.42
maximum: 33.3 Mmol/d January, rel. stdev: 0.49



## Dissolved Inorganic Carbon load for River Ems

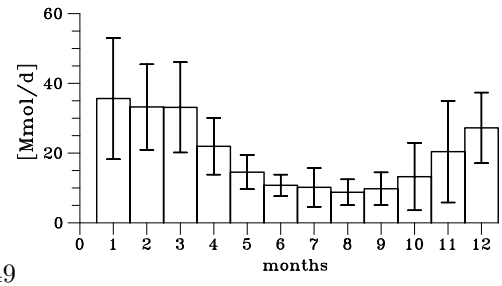
ANNUAL LOADS

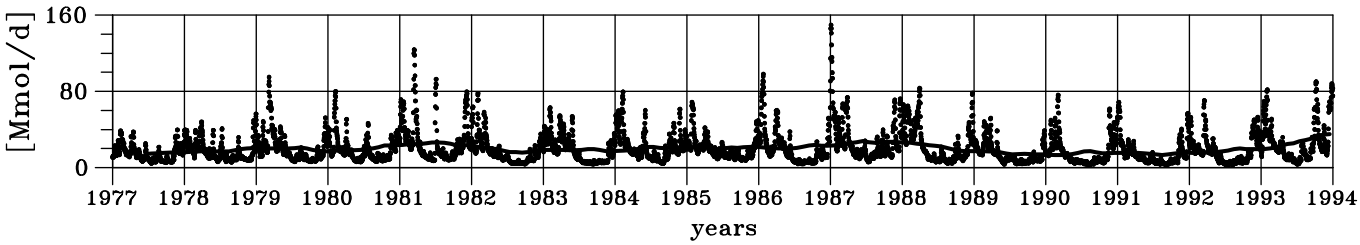
| year | Gmol/y | year | Gmol/y | year | Gmol/y | year | Gmol/y | year | Gmol/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 5.2 | 1984 | 8.0 | 1991 | 5.2 | 1998 | 10.3 | 2005 | 6.3 |
| 1978 | 6.2 | 1985 | 7.1 | 1992 | 6.3 | 1999 | 7.5 | 2006 | 5.3 |
| 1979 | 7.5 | 1986 | 7.3 | 1993 | 9.6 | 2000 | 7.3 | 2007 | 9.1 |
| 1980 | 6.7 | 1987 | 10.3 | 1994 | 11.3 | 2001 | 7.3 | 2008 | 7.0 |
| 1981 | 9.9 | 1988 | 8.6 | 1995 | 8.6 | 2002 | 9.4 | 2009 | 5.4 |
| 1982 | 6.0 | 1989 | 5.1 | 1996 | 4.1 | 2003 | 6.6 | | |
| 1983 | 6.5 | 1990 | 5.8 | 1997 | 5.0 | 2004 | 7.4 | | |

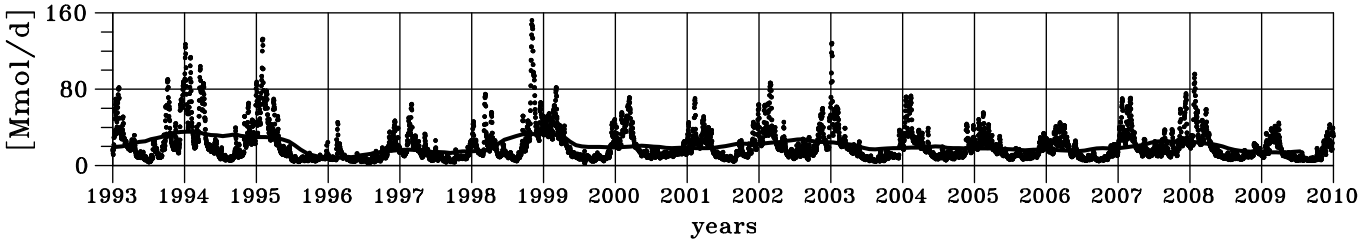
TIME SERIES
mean: 19.8 Mmol/d
relative standard deviation: 0.85
minimum: 2.5 Mmol/d July 30, 1999
maximum: 152.1 Mmold November 3, 1998

LOW PASS
minimum: 8.1 Mmol/d March 1996
maximum: 35.6 Mmol/d January 1994

ANNUAL CYCLE
minimum: 8.8 Mmol/d August, rel. stdev: 0.42
maximum: 35.6 Mmol/d January, rel. stdev: 0.49



## Dissolved Organic Carbon load for River Ems

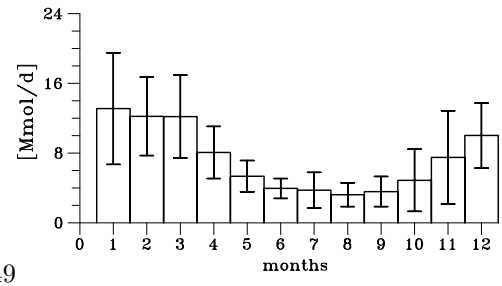
ANNUAL LOADS

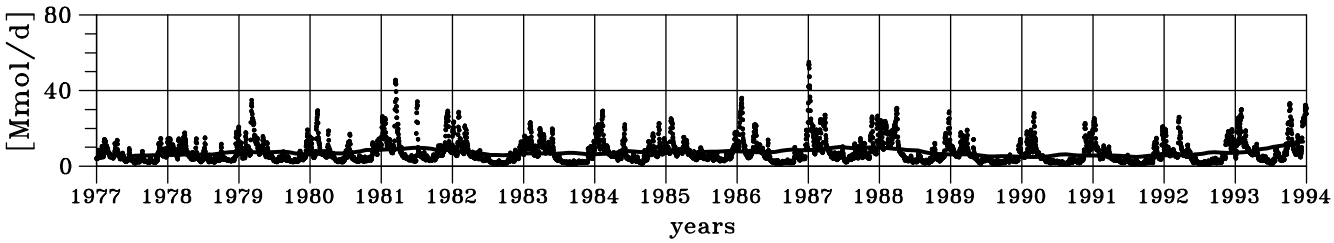
| year | Gmol/y | year | Gmol/y | year | Gmol/y | year | Gmol/y | year | Gmol/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 1.9 | 1984 | 2.9 | 1991 | 1.9 | 1998 | 3.8 | 2005 | 2.3 |
| 1978 | 2.3 | 1985 | 2.6 | 1992 | 2.3 | 1999 | 2.8 | 2006 | 2.0 |
| 1979 | 2.7 | 1986 | 2.7 | 1993 | 3.5 | 2000 | 2.7 | 2007 | 3.3 |
| 1980 | 2.5 | 1987 | 3.8 | 1994 | 4.2 | 2001 | 2.7 | 2008 | 2.6 |
| 1981 | 3.6 | 1988 | 3.2 | 1995 | 3.2 | 2002 | 3.5 | 2009 | 2.0 |
| 1982 | 2.2 | 1989 | 1.9 | 1996 | 1.5 | 2003 | 2.4 | | |
| 1983 | 2.4 | 1990 | 2.1 | 1997 | 1.8 | 2004 | 2.7 | | |

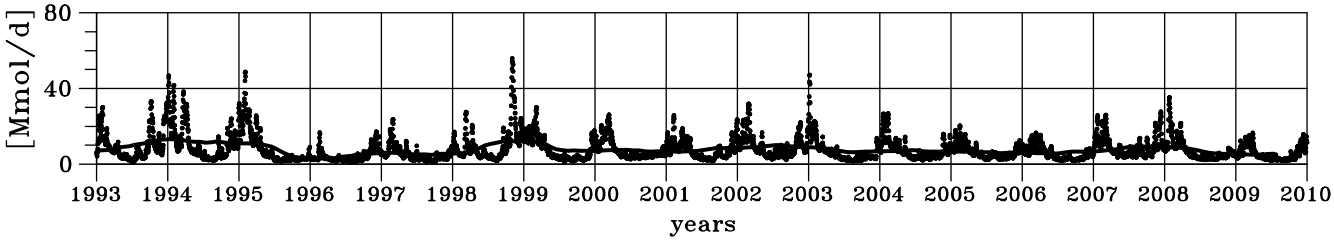
TIME SERIES
mean: 7.3 Mmol/d
relative standard deviation: 0.85
minimum: 0.9 Mmol/d July 30, 1999
maximum: 55.9 Mmold November 3, 1998

LOW PASS
minimum: 3.0 Mmol/d March 1996
maximum: 13.1 Mmol/d January 1994

ANNUAL CYCLE
minimum: 3.2 Mmol/d August, rel. stdev: 0.42
maximum: 13.1 Mmol/d January, rel. stdev: 0.49



## 5.4 Loads of Lake IJssel

### Total Nitrogen load for Lake IJssel

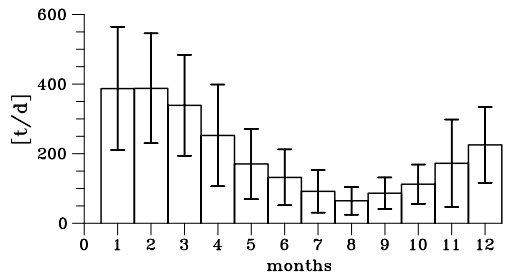
ANNUAL LOADS

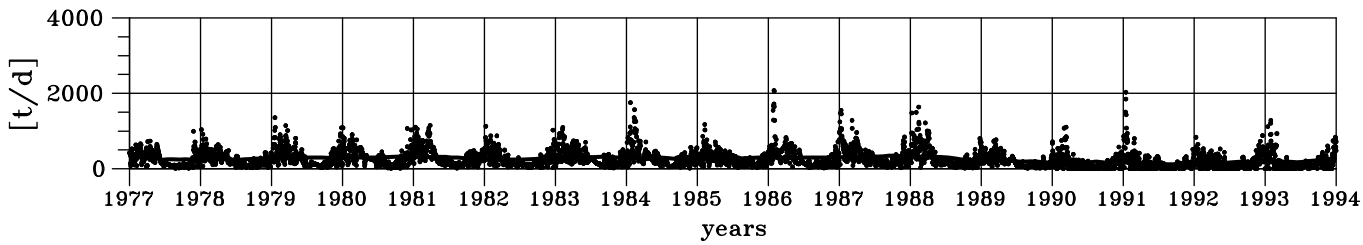
| year | kt/y | year | kt/y | year | kt/y | year | kt/y | year | kt/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 87.0 | 1984 | 110.7 | 1991 | 54.6 | 1998 | 81.8 | 2005 | 40.2 |
| 1978 | 86.0 | 1985 | 86.9 | 1992 | 62.9 | 1999 | 60.3 | 2006 | 34.8 |
| 1979 | 109.7 | 1986 | 105.7 | 1993 | 63.2 | 2000 | 60.9 | 2007 | 48.3 |
| 1980 | 107.6 | 1987 | 121.3 | 1994 | 88.9 | 2001 | 57.7 | 2008 | 47.1 |
| 1981 | 112.0 | 1988 | 112.1 | 1995 | 80.4 | 2002 | 70.3 | 2009 | 31.1 |
| 1982 | 90.1 | 1989 | 70.7 | 1996 | 39.1 | 2003 | 41.1 | | |
| 1983 | 108.9 | 1990 | 58.5 | 1997 | 44.5 | 2004 | 47.5 | | |

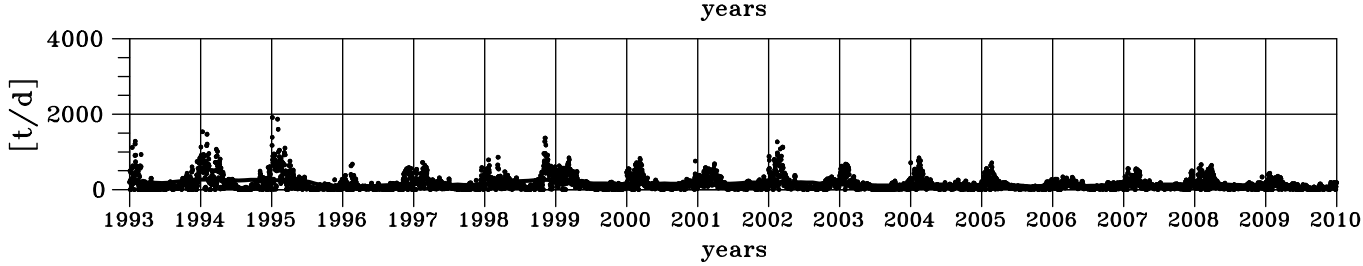
TIME SERIES
mean: 200.9 t/d
relative standard deviation: 1.03
minimum: 0.0 t/d January 26, 1990
maximum: 2077.7 t/d January 29, 1986

LOW PASS
minimum: 70.8 t/d January 1996
maximum: 342.1 t/d September 1987

ANNUAL CYCLE
minimum: 64.7 t/d August, rel. stdev: 0.61
maximum: 387.9 t/d February, rel. stdev: 0.41



## Nitrate + Nitrite load for Lake IJssel

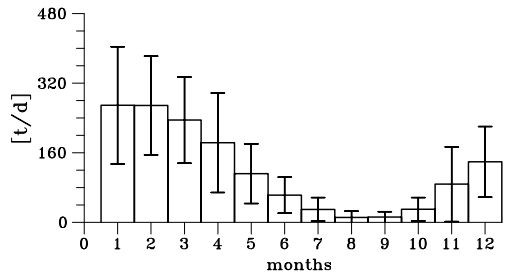
ANNUAL LOADS

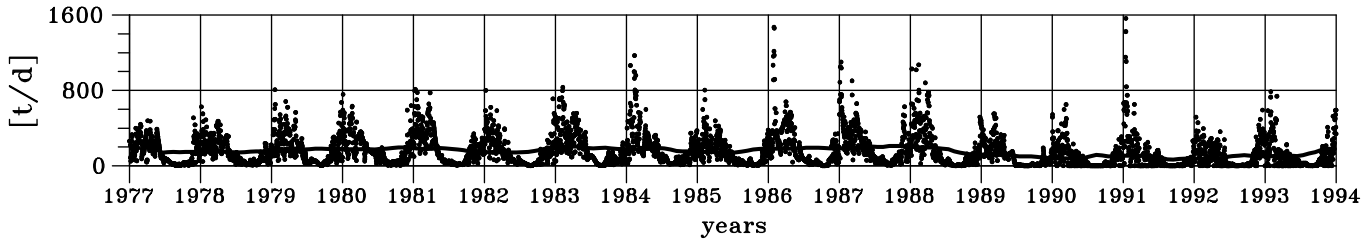
| year | kt/y | year | kt/y | year | kt/y | year | kt/y | year | kt/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 51.4 | 1984 | 69.7 | 1991 | 35.1 | 1998 | 49.5 | 2005 | 24.0 |
| 1978 | 51.3 | 1985 | 47.4 | 1992 | 37.5 | 1999 | 36.2 | 2006 | 19.2 |
| 1979 | 64.1 | 1986 | 66.8 | 1993 | 36.3 | 2000 | 35.5 | 2007 | 25.6 |
| 1980 | 62.7 | 1987 | 75.0 | 1994 | 61.9 | 2001 | 37.6 | 2008 | 27.7 |
| 1981 | 66.4 | 1988 | 65.7 | 1995 | 52.5 | 2002 | 40.5 | 2009 | 14.4 |
| 1982 | 52.9 | 1989 | 37.1 | 1996 | 21.6 | 2003 | 23.4 | | |
| 1983 | 66.5 | 1990 | 32.0 | 1997 | 27.9 | 2004 | 22.8 | | |

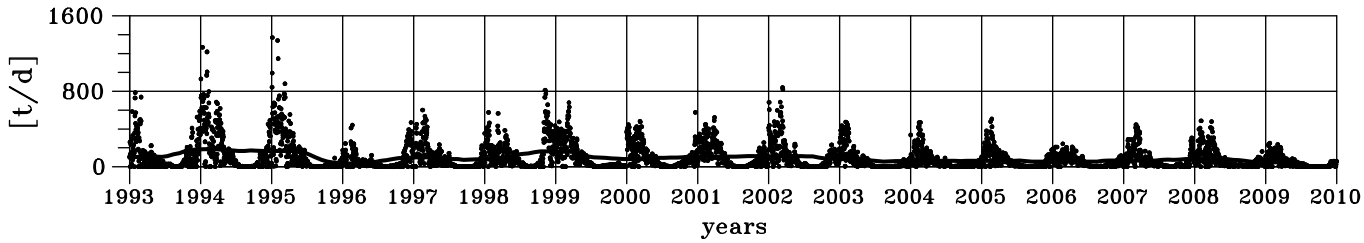
TIME SERIES
mean: 119.3 t/d
relative standard deviation: 1.28
minimum: 0.0 t/d September 22, 1988
maximum: 1562.4 t/d January 15, 1991

LOW PASS
minimum: 33.9 t/d February 1996
maximum: 210.6 t/d October 1987

ANNUAL CYCLE
minimum: 11.2 t/d August, rel. stdev: 1.28
maximum: 268.9 t/d January, rel. stdev: 0.50



## Ammonium load for Lake IJssel

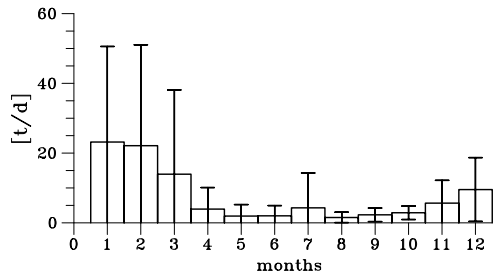
ANNUAL LOADS

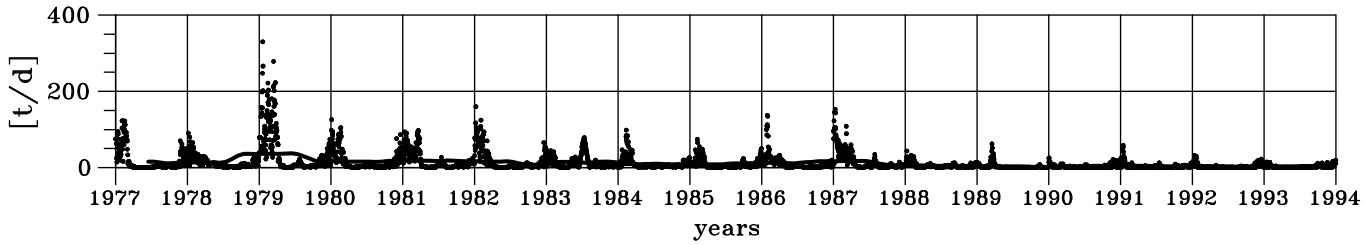
| year | t/y | year | t/y | year | t/y | year | t/y | year | t/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 5919 | 1984 | 3610 | 1991 | 1305 | 1998 | 1811 | 2005 | 547 |
| 1978 | 4320 | 1985 | 3155 | 1992 | 1200 | 1999 | 1374 | 2006 | 439 |
| 1979 | 13896 | 1986 | 3831 | 1993 | 1007 | 2000 | 1109 | 2007 | 459 |
| 1980 | 5791 | 1987 | 6285 | 1994 | 1270 | 2001 | 1791 | 2008 | 496 |
| 1981 | 5941 | 1988 | 1778 | | | 2002 | 2061 | 2009 | 431 |
| 1982 | 5999 | 1989 | 1019 | | | 2003 | 1094 | | |
| 1983 | 4793 | 1990 | 1176 | | | 2004 | 576 | | |

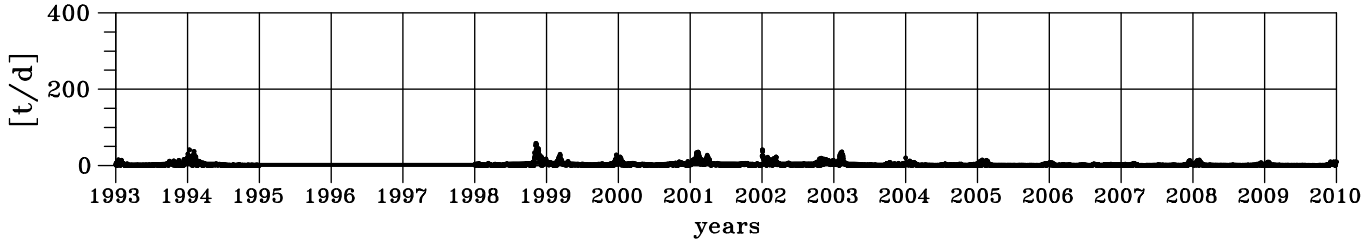
TIME SERIES
mean: 8.0 t/d
relative standard deviation: 2.17
minimum: 0.0 t/d April 13, 1977
maximum: 330.1 t/d January 19, 1979

LOW PASS
minimum: 0.8 t/d May 2009
maximum: 38.0 t/d June 1979

ANNUAL CYCLE
minimum: 1.5 t/d August, rel. stdev: 0.96
maximum: 23.2 t/d January, rel. stdev: 1.18



## Total Phosphorus load for Lake IJssel

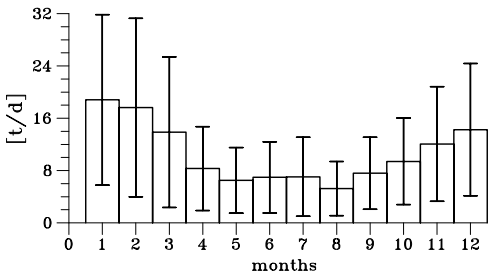
ANNUAL LOADS

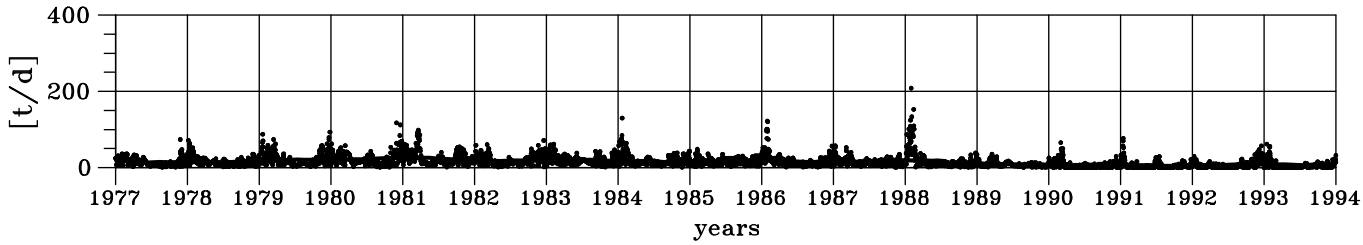
| year | kt/y | year | kt/y | year | kt/y | year | kt/y | year | kt/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 5.0 | 1984 | 6.6 | 1991 | 2.0 | 1998 | 3.2 | 2005 | 1.5 |
| 1978 | 5.2 | 1985 | 5.5 | 1992 | 2.8 | 1999 | 2.3 | 2006 | 1.1 |
| 1979 | 7.6 | 1986 | 6.0 | 1993 | 2.2 | 2000 | 2.9 | 2007 | 1.7 |
| 1980 | 8.2 | 1987 | 5.3 | 1994 | 3.9 | 2001 | 1.5 | 2008 | 1.6 |
| 1981 | 8.5 | 1988 | 6.9 | 1995 | 2.9 | 2002 | 3.2 | 2009 | 2.4 |
| 1982 | 6.8 | 1989 | 3.0 | 1996 | 1.7 | 2003 | 1.6 | | |
| 1983 | 7.1 | 1990 | 2.6 | 1997 | 1.5 | 2004 | 3.3 | | |

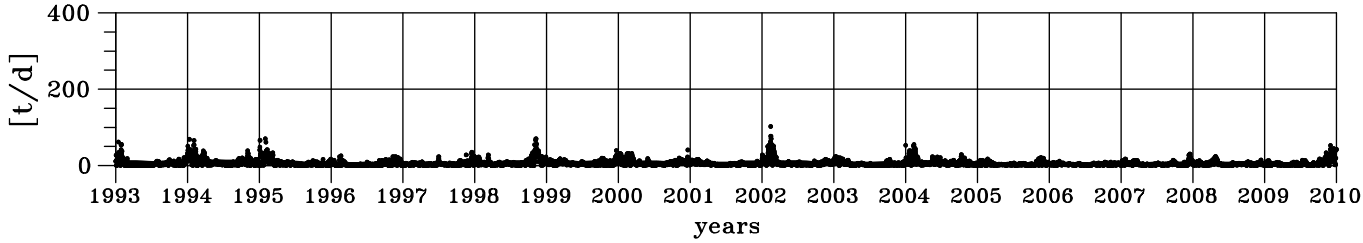
TIME SERIES
mean: 10.6 t/d
relative standard deviation: 1.15
minimum: 0.0 t/d January 26, 1990
maximum: 208.3 t/d February 1, 1988

LOW PASS
minimum: 3.1 t/d June 2006
maximum: 26.0 t/d May 1981

ANNUAL CYCLE
minimum: 5.2 t/d August, rel. stdev: 0.79
maximum: 18.8 t/d January, rel. stdev: 0.69



## Phosphate load for Lake IJssel

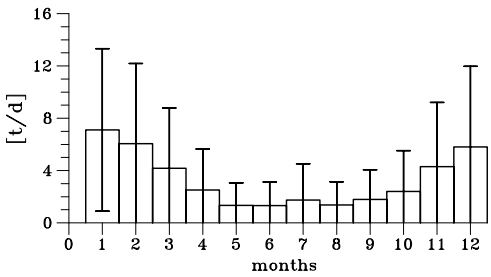
ANNUAL LOADS

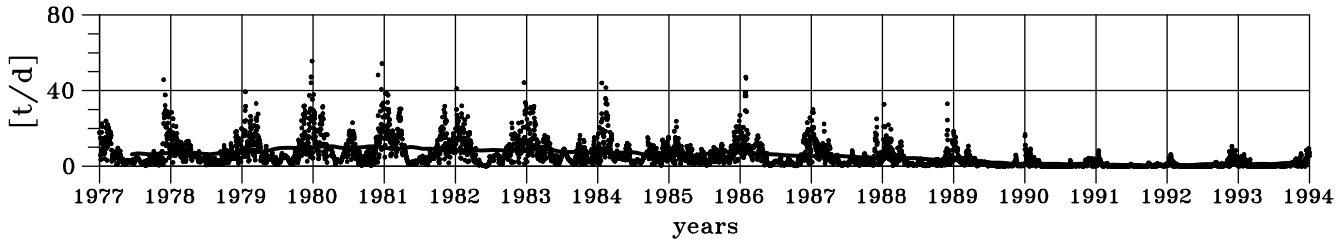
| year | t/y | year | t/y | year | t/y | year | t/y | year | t/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 2456 | 1984 | 2729 | 1991 | 170 | 1998 | 951 | 2005 | 226 |
| 1978 | 2260 | 1985 | 2207 | 1992 | 386 | 1999 | 608 | 2006 | 74 |
| 1979 | 3473 | 1986 | 2237 | 1993 | 389 | 2000 | 426 | 2007 | 225 |
| 1980 | 3521 | 1987 | 1887 | 1994 | 626 | 2001 | 297 | 2008 | 198 |
| 1981 | 3454 | 1988 | 1532 | 1995 | 727 | 2002 | 752 | 2009 | 89 |
| 1982 | 3179 | 1989 | 738 | 1996 | 334 | 2003 | 264 | | |
| 1983 | 2713 | 1990 | 473 | 1997 | 180 | 2004 | 165 | | |

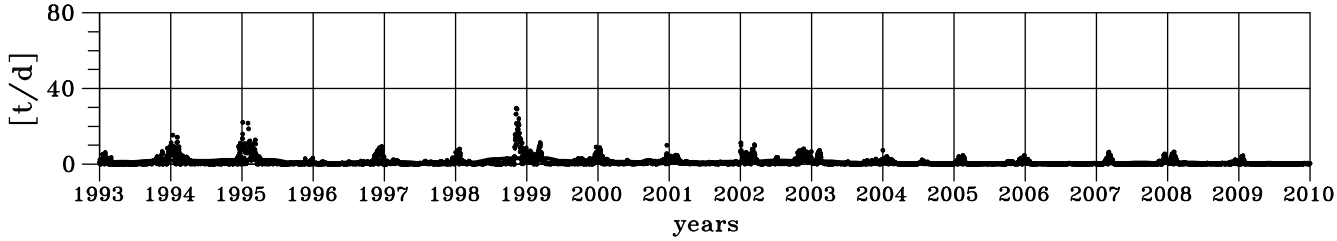
TIME SERIES
mean: 3.3 t/d
relative standard deviation: 1.61
minimum: 0.0 t/d June 8, 1982
maximum: 55.6 t/d December 27, 1979

LOW PASS
minimum: 0.2 t/d August 2006
maximum: 10.5 t/d March 1980

ANNUAL CYCLE
minimum: 1.3 t/d June, rel. stdev: 1.38
maximum: 7.1 t/d January, rel. stdev: 0.87



## Silicate load for Lake IJssel

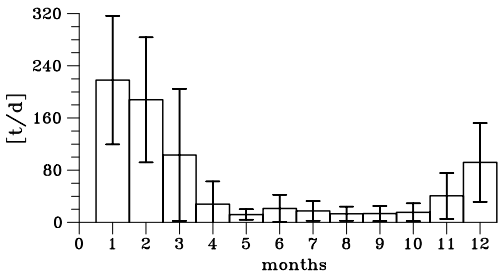
ANNUAL LOADS

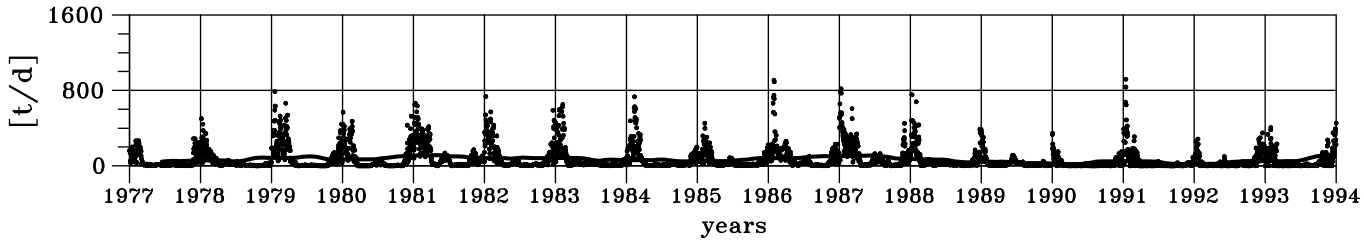
| year | kt/y | year | kt/y | year | kt/y | year | kt/y | year | kt/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 16.9 | 1984 | 24.9 | 1991 | 16.1 | | | 2005 | 19.7 |
| 1978 | 15.4 | 1985 | 17.7 | 1992 | 14.5 | 1999 | 33.3 | 2006 | 9.3 |
| 1979 | 36.6 | 1986 | 30.5 | 1993 | 18.2 | 2000 | 21.3 | 2007 | 25.0 |
| 1980 | 26.3 | 1987 | 40.2 | 1994 | 31.4 | 2001 | 25.6 | 2008 | 17.1 |
| 1981 | 37.4 | 1988 | 23.9 | | | 2002 | 37.0 | 2009 | 13.3 |
| 1982 | 31.6 | 1989 | 11.2 | | | 2003 | 23.3 | | |
| 1983 | 23.0 | 1990 | 8.8 | | | 2004 | 17.7 | | |

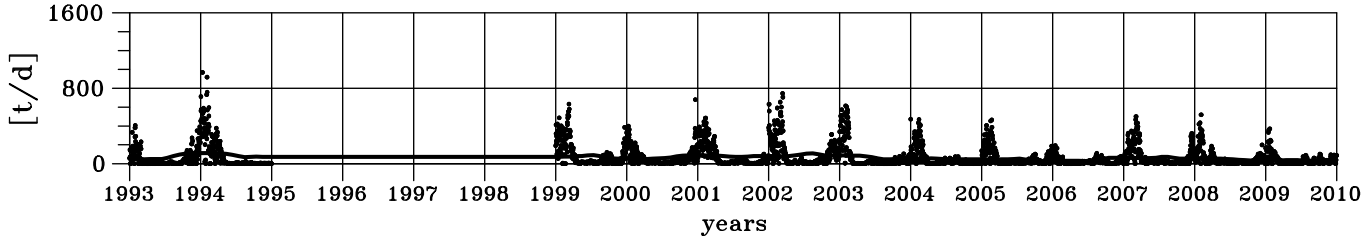
TIME SERIES
mean: 63.2 t/d
relative standard deviation: 1.59
minimum: 0.0 t/d April 13, 1978
maximum: 968.7 t/d January 11, 1994

LOW PASS
minimum: 17.9 t/d April 1990
maximum: 114.3 t/d May 1981

ANNUAL CYCLE
minimum: 12.0 t/d May, rel. stdev: 0.66
maximum: 218.0 t/d January, rel. stdev: 0.45



## 5.5 Loads of Nordzeekanaal

### Total Nitrogen load for Nordzeekanaal

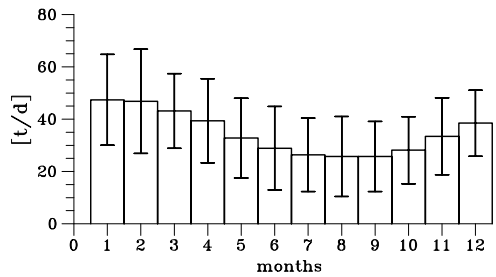
ANNUAL LOADS

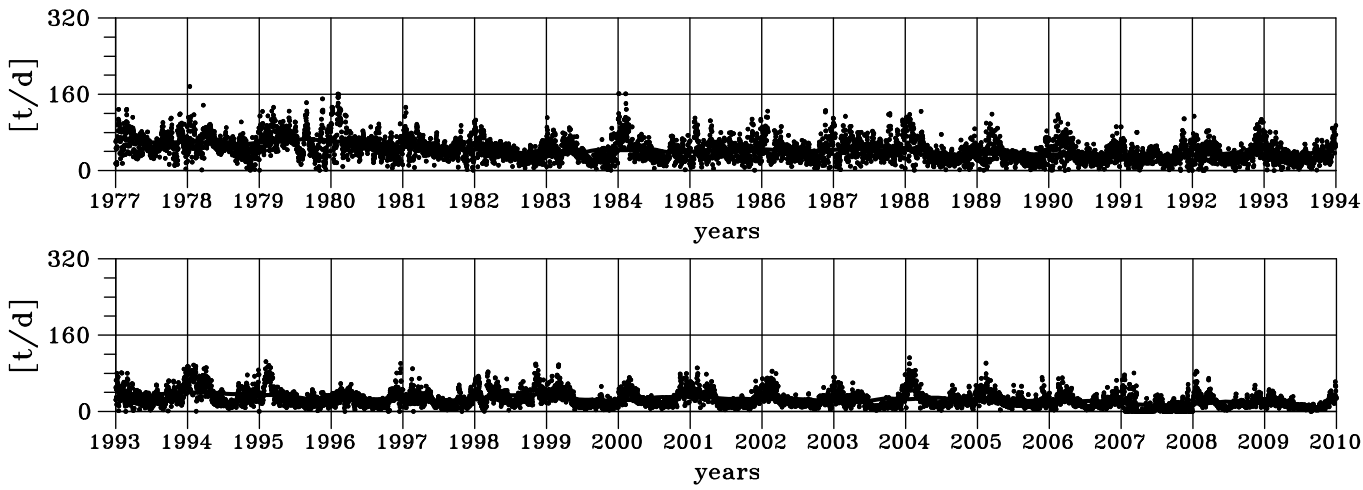
| year | kt/y | year | kt/y | year | kt/y | year | kt/y | year | kt/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 21.7 | 1984 | 16.4 | 1991 | 11.2 | 1998 | 12.5 | 2005 | 9.1 |
| 1978 | 19.6 | 1985 | 16.0 | 1992 | 13.4 | 1999 | 9.0 | 2006 | 7.7 |
| 1979 | 23.3 | 1986 | 15.4 | 1993 | 11.9 | 2000 | 10.7 | 2007 | 4.1 |
| 1980 | 20.7 | 1987 | 17.4 | 1994 | 14.0 | 2001 | 9.6 | 2008 | 7.7 |
| 1981 | 17.4 | 1988 | 13.8 | 1995 | 10.9 | 2002 | 9.4 | 2009 | 5.6 |
| 1982 | 13.9 | 1989 | 11.9 | 1996 | 9.5 | 2003 | 8.1 | | |
| 1983 | 13.5 | 1990 | 13.2 | 1997 | 8.3 | 2004 | 10.3 | | |

TIME SERIES
mean: 34.6 t/d
relative standard deviation: 0.65
minimum: 0.0 t/d March 24, 1990
maximum: 176.2 t/d January 13, 1978

LOW PASS
minimum: 11.7 t/d July 2007
maximum: 66.5 t/d September 1979

ANNUAL CYCLE
minimum: 25.7 t/d September, rel. stdev: 0.52
maximum: 47.4 t/d January, rel. stdev: 0.37



## Nitrate + Nitrite load for Nordzeekanaal

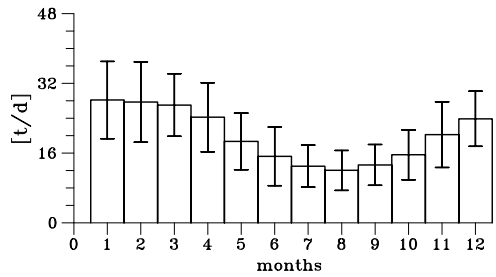
ANNUAL LOADS

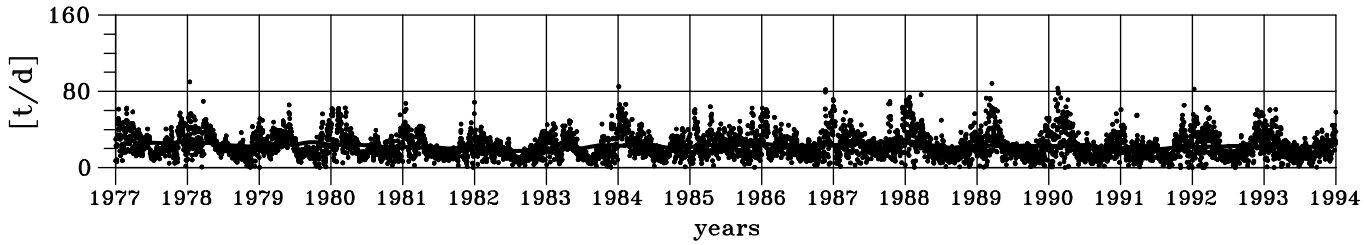
| year | kt/y | year | kt/y | year | kt/y | year | kt/y | year | kt/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 9.5 | 1984 | 8.8 | 1991 | 7.0 | 1998 | 8.5 | 2005 | 6.5 |
| 1978 | 8.8 | 1985 | 9.0 | 1992 | 8.4 | 1999 | 6.6 | 2006 | 5.3 |
| 1979 | 8.8 | 1986 | 8.7 | 1993 | 7.4 | 2000 | 7.2 | 2007 | 2.9 |
| 1980 | 8.5 | 1987 | 9.0 | 1994 | 9.1 | 2001 | 6.4 | 2008 | 4.9 |
| 1981 | 7.7 | 1988 | 8.4 | 1995 | 7.2 | 2002 | 6.3 | 2009 | 3.8 |
| 1982 | 6.3 | 1989 | 8.0 | 1996 | 6.6 | 2003 | 4.9 | | |
| 1983 | 7.2 | 1990 | 8.6 | 1997 | 6.0 | 2004 | 7.4 | | |

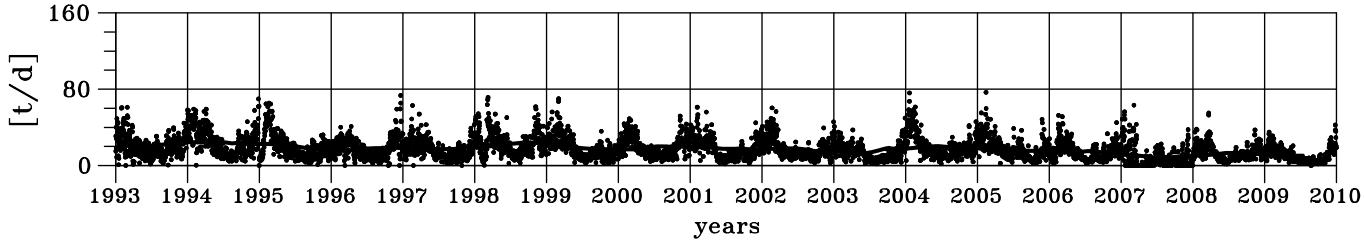
TIME SERIES
mean: 19.9 t/d
relative standard deviation: 0.62
minimum: 0.0 t/d March 24, 1990
maximum: 90.0 t/d January 13, 1978

LOW PASS
minimum: 7.7 t/d August 2007
maximum: 27.1 t/d February 1978

ANNUAL CYCLE
minimum: 12.0 t/d August, rel. stdev: 0.38
maximum: 28.2 t/d January, rel. stdev: 0.32



## Ammonium load for Nordzeekanaal

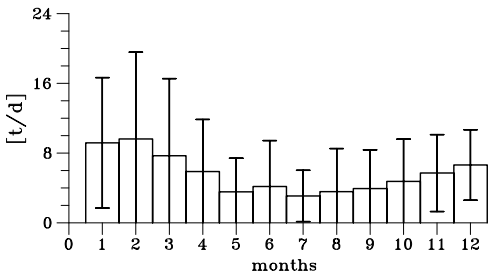
ANNUAL LOADS

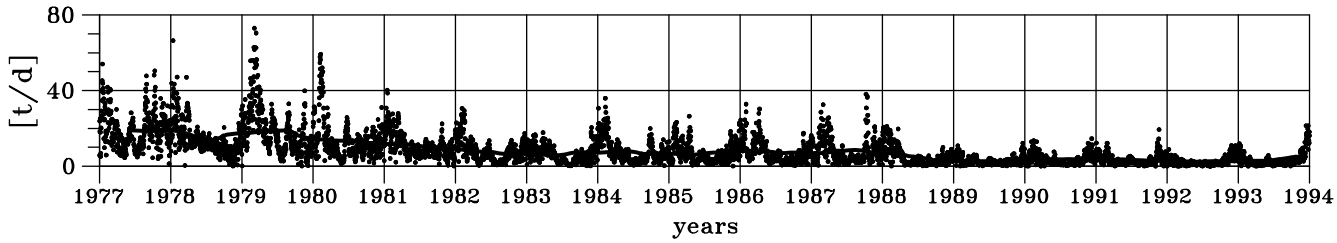
| year | t/y | year | t/y | year | t/y | year | t/y | year | t/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 6883 | 1984 | 2853 | 1991 | 1245 | 1998 | 650 | 2005 | 560 |
| 1978 | 5150 | 1985 | 2407 | 1992 | 922 | 1999 | 669 | 2006 | 1075 |
| 1979 | 6802 | 1986 | 2720 | 1993 | 1196 | 2000 | 819 | 2007 | 367 |
| 1980 | 4990 | 1987 | 2971 | 1994 | 1510 | 2001 | 883 | 2008 | 750 |
| 1981 | 3920 | 1988 | 1803 | | | 2002 | 718 | 2009 | 1020 |
| 1982 | 2782 | 1989 | 995 | | | 2003 | 586 | | |
| 1983 | 2125 | 1990 | 1307 | | | 2004 | 992 | | |

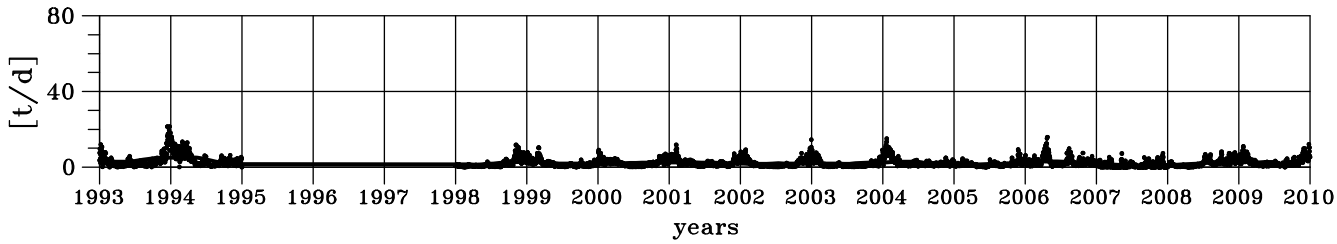
TIME SERIES
mean: 5.8 t/d
relative standard deviation: 1.16
minimum: 0.0 t/d March 24, 1990
maximum: 72.9 t/d March 5, 1979

LOW PASS
minimum: 0.9 t/d December 2007
maximum: 19.1 t/d November 1977

ANNUAL CYCLE
minimum: 3.1 t/d July, rel. stdev: 0.96
maximum: 9.6 t/d February, rel. stdev: 1.04



## Total Phosphorus load for Nordzeekanaal

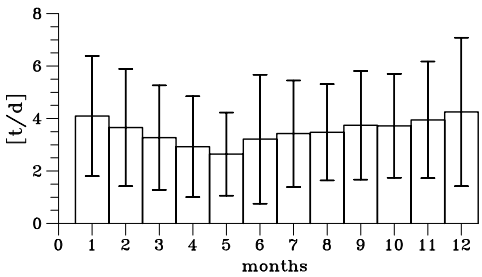
ANNUAL LOADS

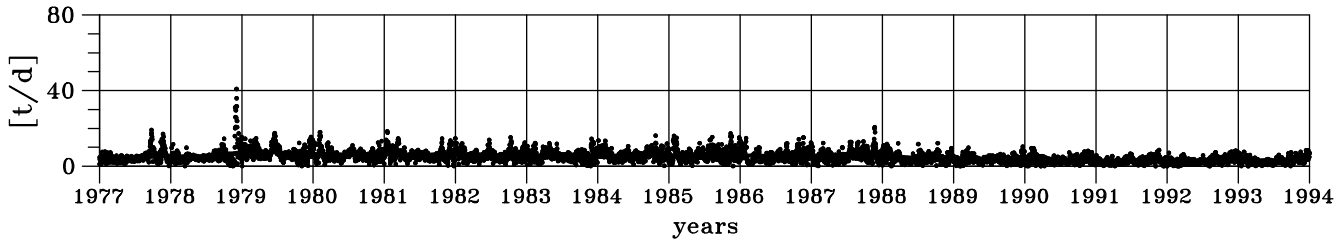
| year | t/y | year | t/y | year | t/y | year | t/y | year | t/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 1824 | 1984 | 2153 | 1991 | 1071 | 1998 | 1008 | 2005 | 676 |
| 1978 | 2109 | 1985 | 2283 | 1992 | 1113 | 1999 | 789 | 2006 | 647 |
| 1979 | 2612 | 1986 | 1947 | 1993 | 1148 | 2000 | 761 | 2007 | 282 |
| 1980 | 2220 | 1987 | 2093 | 1994 | 1322 | 2001 | 754 | 2008 | 551 |
| 1981 | 2307 | 1988 | 1623 | 1995 | 703 | 2002 | 841 | 2009 | 411 |
| 1982 | 2117 | 1989 | 1256 | 1996 | 643 | 2003 | 619 | | |
| 1983 | 1917 | 1990 | 1212 | 1997 | 744 | 2004 | 788 | | |

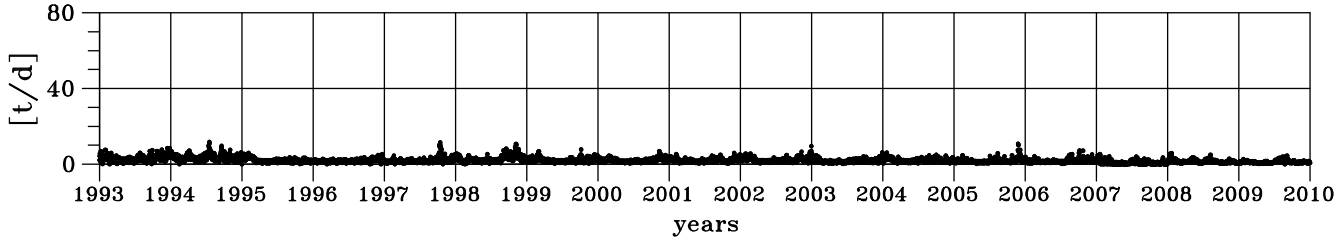
TIME SERIES
mean: 3.5 t/d
relative standard deviation: 0.79
minimum: 0.0 t/d March 24, 1990
maximum: 40.8 t/d December 4, 1978

LOW PASS
minimum: 0.8 t/d July 2007
maximum: 7.8 t/d February 1979

ANNUAL CYCLE
minimum: 2.6 t/d May, rel. stdev: 0.60
maximum: 4.2 t/d December, rel. stdev: 0.67



## Phosphate load for Nordzeekanaal

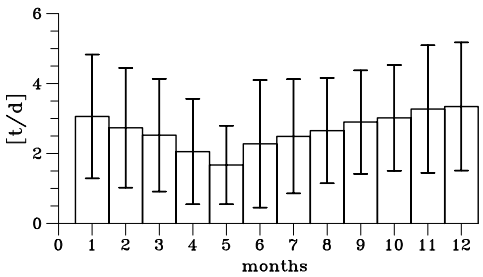
ANNUAL LOADS

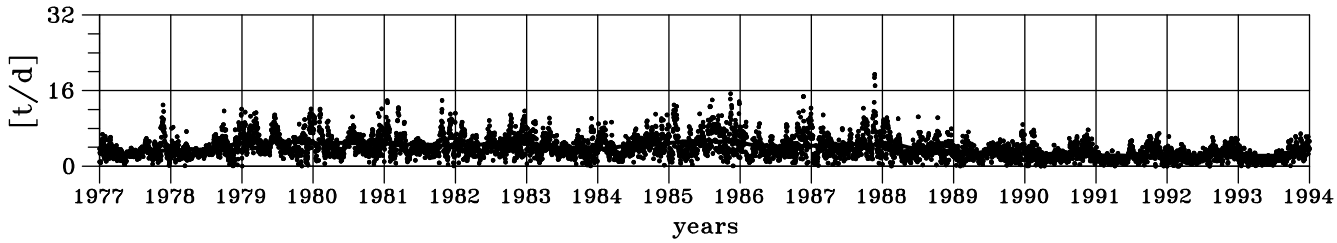
| year | t/y | year | t/y | year | t/y | year | t/y | year | t/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 1200 | 1984 | 1634 | 1991 | 794 | 1998 | 746 | 2005 | 527 |
| 1978 | 1313 | 1985 | 1987 | 1992 | 868 | 1999 | 632 | 2006 | 504 |
| 1979 | 1893 | 1986 | 1556 | 1993 | 804 | 2000 | 571 | 2007 | 234 |
| 1980 | 1766 | 1987 | 1633 | 1994 | 854 | 2001 | 521 | 2008 | 396 |
| 1981 | 1707 | 1988 | 1387 | 1995 | 507 | 2002 | 665 | 2009 | 335 |
| 1982 | 1684 | 1989 | 1034 | 1996 | 495 | 2003 | 496 | | |
| 1983 | 1405 | 1990 | 945 | 1997 | 492 | 2004 | 543 | | |

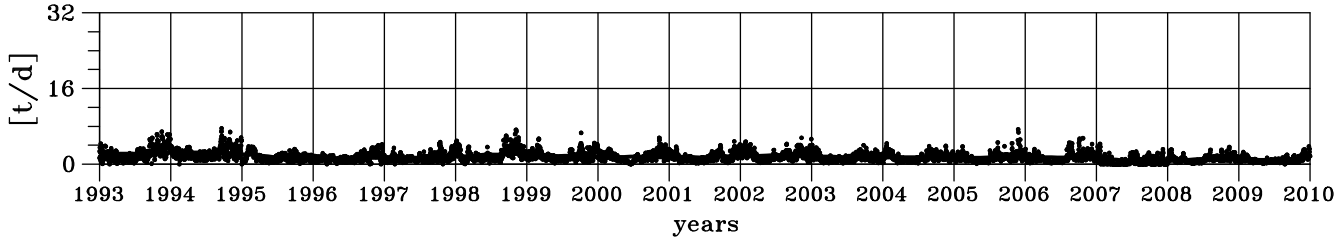
TIME SERIES
mean: 2.7 t/d
relative standard deviation: 0.79
minimum: 0.0 t/d March 24, 1990
maximum: 19.4 t/d November 22, 1987

LOW PASS
minimum: 0.6 t/d August 2007
maximum: 5.5 t/d July 1985

ANNUAL CYCLE
minimum: 1.7 t/d May, rel. stdev: 0.67
maximum: 3.3 t/d December, rel. stdev: 0.55



## Silicate load for Nordzeekanaal

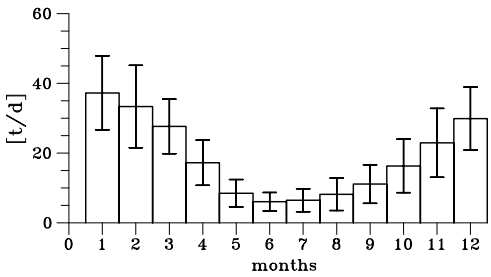
ANNUAL LOADS

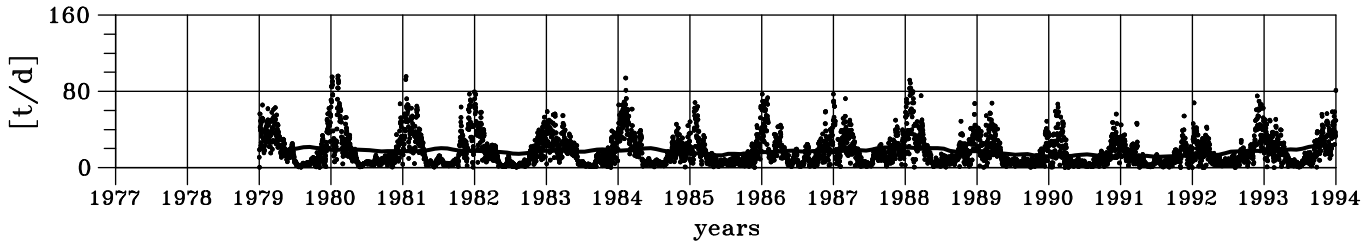
| year | kt/y | year | kt/y | year | kt/y | year | kt/y | year | kt/y |
|---|---|---|---|---|---|---|---|---|---|
| | | 1984 | 7.4 | 1991 | 4.1 | | | 2005 | 8.7 |
| | | 1985 | 4.9 | 1992 | 6.1 | 1999 | 8.2 | 2006 | 8.2 |
| 1979 | 7.1 | 1986 | 6.5 | 1993 | 6.7 | 2000 | 8.6 | 2007 | 4.9 |
| 1980 | 6.6 | 1987 | 6.5 | 1994 | 8.1 | 2001 | 7.8 | 2008 | 7.9 |
| 1981 | 7.4 | 1988 | 7.7 | | | 2002 | 9.0 | 2009 | 6.4 |
| 1982 | 5.5 | 1989 | 5.0 | | | 2003 | 5.6 | | |
| 1983 | 5.9 | 1990 | 4.9 | | | 2004 | 8.9 | | |

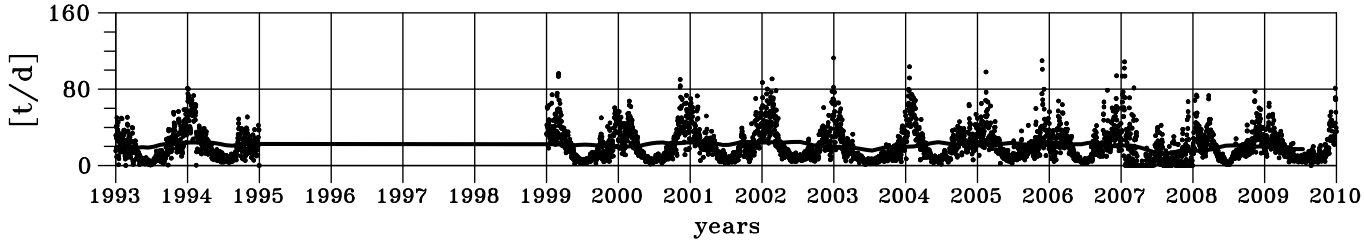
TIME SERIES
mean: 17.3 t/d
relative standard deviation: 0.89
minimum: 0.0 t/d March 24, 1990
maximum: 112.8 t/d December 31, 2002

LOW PASS
minimum: 11.4 t/d July 1991
maximum: 24.8 t/d June 2002

ANNUAL CYCLE
minimum: 6.1 t/d June, rel. stdev: 0.43
maximum: 37.3 t/d January, rel. stdev: 0.29



## 5.6 Loads of Nieuwe Waterweg

### Total Nitrogen load for Nieuwe Waterweg

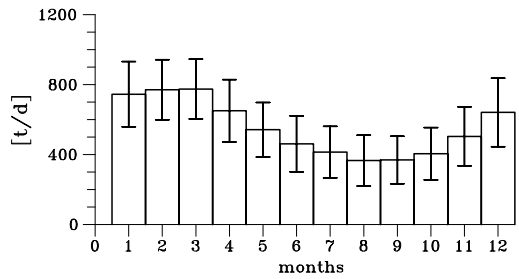
ANNUAL LOADS

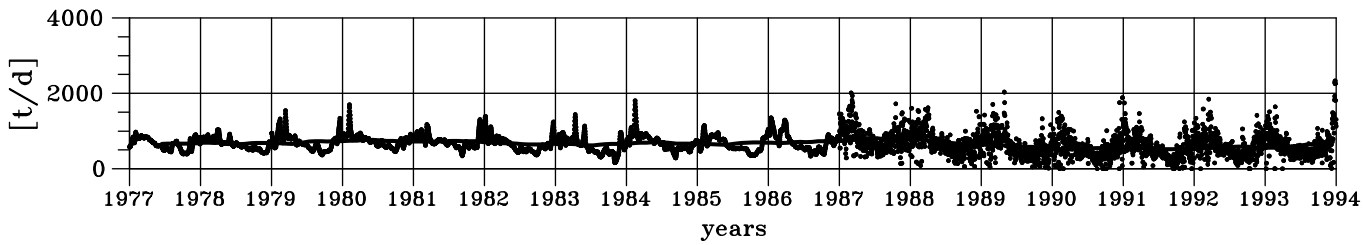
| year | kt/y | year | kt/y | year | kt/y | year | kt/y | year | kt/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 241.4 | 1984 | 258.1 | 1991 | 192.9 | 1998 | 144.5 | 2005 | 131.5 |
| 1978 | 239.3 | 1985 | 236.4 | 1992 | 212.1 | 1999 | 148.9 | 2006 | 146.1 |
| 1979 | 260.0 | 1986 | 259.7 | 1993 | 226.5 | 2000 | 159.3 | 2007 | 158.0 |
| 1980 | 275.0 | 1987 | 294.8 | 1994 | 234.3 | 2001 | 169.2 | 2008 | 149.1 |
| 1981 | 267.8 | 1988 | 251.5 | 1995 | 214.2 | 2002 | 181.8 | 2009 | 135.1 |
| 1982 | 239.4 | 1989 | 218.0 | 1996 | 180.3 | 2003 | 103.8 | | |
| 1983 | 223.6 | 1990 | 193.5 | 1997 | 168.9 | 2004 | 145.3 | | |

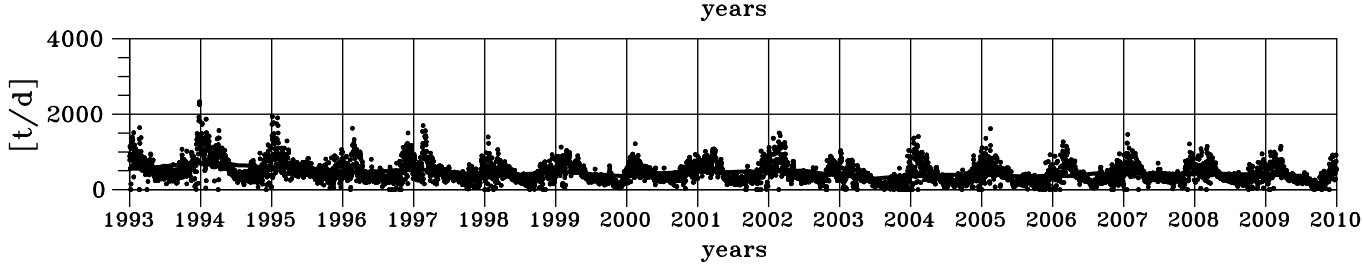
TIME SERIES
mean: 552.6 t/d
relative standard deviation: 0.51
minimum: 0.0 t/d February 8, 1990
maximum: 2327.9 t/d December 27, 1993

LOW PASS
minimum: 290.6 t/d June 2003
maximum: 805.7 t/d June 1987

ANNUAL CYCLE
minimum: 365.6 t/d August, rel. stdev: 0.40
maximum: 774.7 t/d March, rel. stdev: 0.22



## Nitrate + Nitrite load for Nieuwe Waterweg

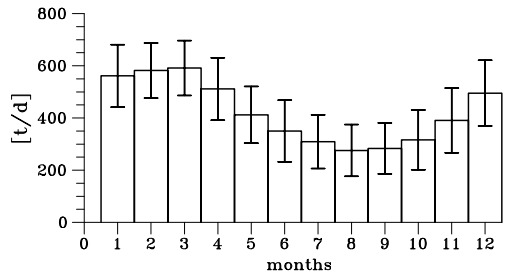
ANNUAL LOADS

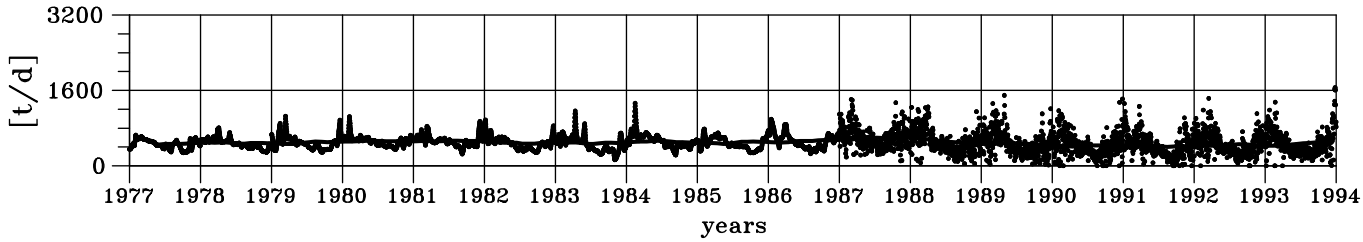
| year | kt/y | year | kt/y | year | kt/y | year | kt/y | year | kt/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 167.2 | 1984 | 195.0 | 1991 | 150.9 | 1998 | 117.0 | 2005 | 107.2 |
| 1978 | 173.5 | 1985 | 173.5 | 1992 | 162.9 | 1999 | 116.2 | 2006 | 122.9 |
| 1979 | 181.3 | 1986 | 192.6 | 1993 | 172.2 | 2000 | 131.2 | 2007 | 130.6 |
| 1980 | 191.7 | 1987 | 218.7 | 1994 | 179.1 | 2001 | 135.2 | 2008 | 128.7 |
| 1981 | 194.1 | 1988 | 187.4 | 1995 | 161.0 | 2002 | 143.0 | 2009 | 111.2 |
| 1982 | 174.7 | 1989 | 172.7 | 1996 | 140.1 | 2003 | 80.7 | | |
| 1983 | 168.5 | 1990 | 152.6 | 1997 | 139.2 | 2004 | 117.3 | | |

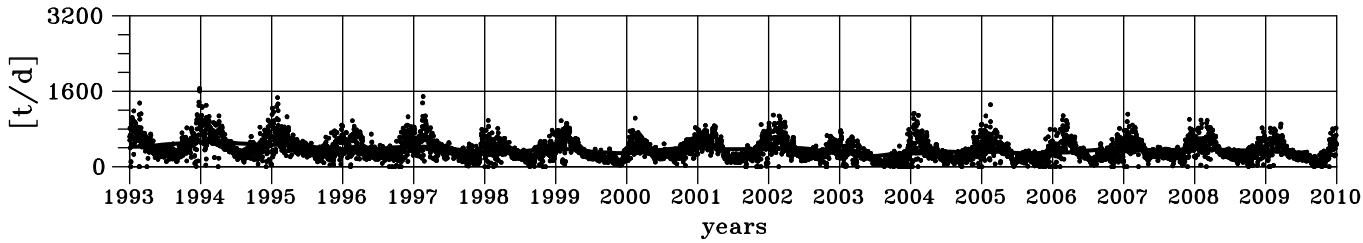
TIME SERIES
mean: 422.3 t/d
relative standard deviation: 0.49
minimum: 0.0 t/d February 8, 1990
maximum: 1658.1 t/d December 27, 1993

LOW PASS
minimum: 226.2 t/d June 2003
maximum: 602.0 t/d November 1987

ANNUAL CYCLE
minimum: 275.5 t/d August, rel. stdev: 0.36
maximum: 591.5 t/d March, rel. stdev: 0.18



## Ammonium load for Nieuwe Waterweg

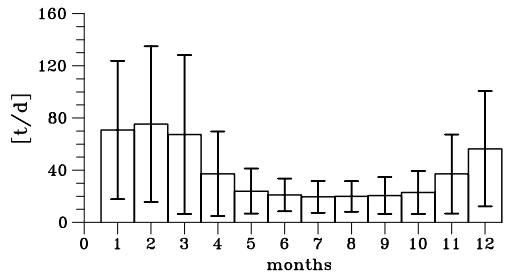
ANNUAL LOADS

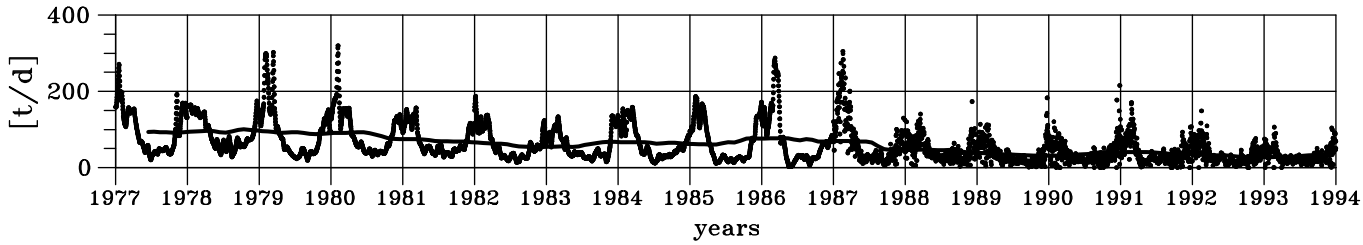
| year | kt/y | year | kt/y | year | kt/y | year | kt/y | year | kt/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 35.1 | 1984 | 22.9 | 1991 | 14.0 | 1998 | 5.0 | 2005 | 3.7 |
| 1978 | 33.2 | 1985 | 24.1 | 1992 | 11.5 | 1999 | 5.2 | 2006 | 4.8 |
| 1979 | 33.5 | 1986 | 25.9 | 1993 | 10.9 | 2000 | 5.7 | 2007 | 3.2 |
| 1980 | 33.7 | 1987 | 24.6 | 1994 | 9.7 | 2001 | 7.8 | 2008 | 3.4 |
| 1981 | 25.1 | 1988 | 16.6 | 1995 | 7.8 | 2002 | 6.1 | 2009 | 3.8 |
| 1982 | 21.9 | 1989 | 12.5 | 1996 | 9.3 | 2003 | 4.8 | | |
| 1983 | 21.0 | 1990 | 12.7 | 1997 | 7.3 | 2004 | 5.5 | | |

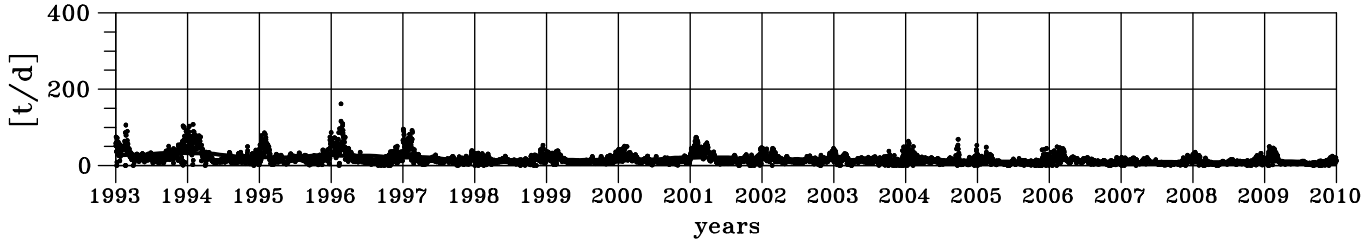
TIME SERIES
mean: 39.2 t/d
relative standard deviation: 1.10
minimum: 0.0 t/d February 8, 1990
maximum: 319.5 t/d February 6, 1980

LOW PASS
minimum: 7.9 t/d December 2007
maximum: 100.3 t/d October 1978

ANNUAL CYCLE
minimum: 19.7 t/d July, rel. stdev: 0.62
maximum: 75.3 t/d February, rel. stdev: 0.79



## Total Phosphorus load for Nieuwe Waterweg

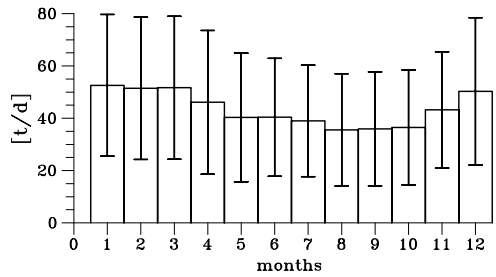
ANNUAL LOADS

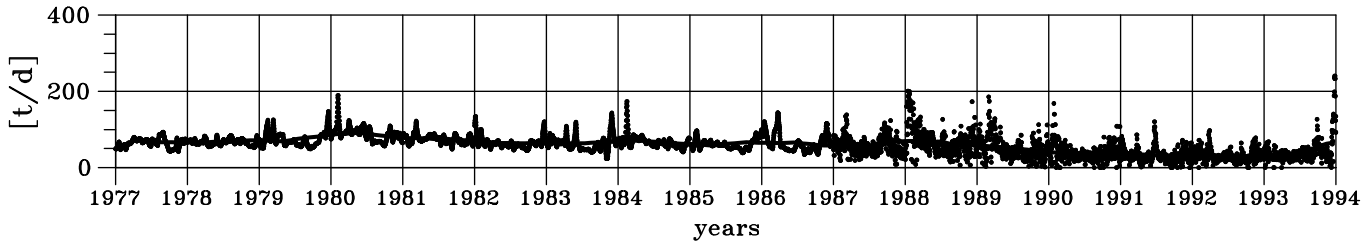
| year | kt/y | year | kt/y | year | kt/y | year | kt/y | year | kt/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 23.6 | 1984 | 24.7 | 1991 | 11.7 | 1998 | 8.8 | 2005 | 6.0 |
| 1978 | 24.5 | 1985 | 22.3 | 1992 | 11.4 | 1999 | 9.9 | 2006 | 6.4 |
| 1979 | 27.0 | 1986 | 23.8 | 1993 | 15.0 | 2000 | 8.8 | 2007 | 8.6 |
| 1980 | 32.5 | 1987 | 20.6 | 1994 | 21.2 | 2001 | 5.6 | 2008 | 7.7 |
| 1981 | 27.3 | 1988 | 25.4 | 1995 | 16.8 | 2002 | 11.7 | 2009 | 6.0 |
| 1982 | 23.7 | 1989 | 18.2 | 1996 | 14.8 | 2003 | 5.2 | | |
| 1983 | 23.2 | 1990 | 13.9 | 1997 | 10.5 | 2004 | 8.3 | | |

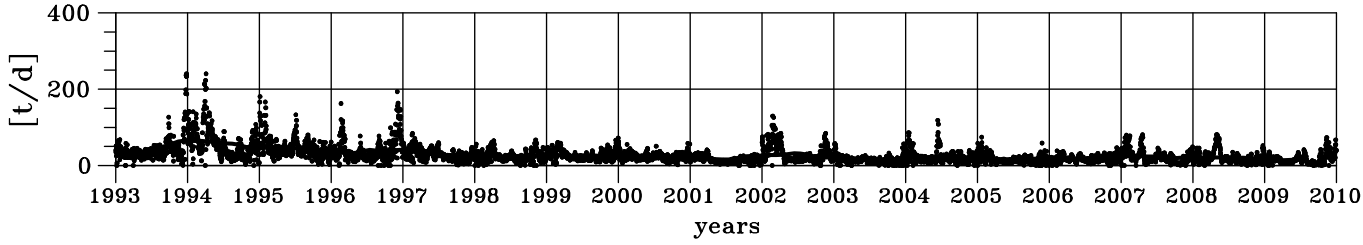
TIME SERIES
mean: 43.5 t/d
relative standard deviation: 0.67
minimum: 0.0 t/d February 8, 1990
maximum: 240.6 t/d December 27, 1993

LOW PASS
minimum: 14.0 t/d April 2009
maximum: 91.0 t/d May 1980

ANNUAL CYCLE
minimum: 35.5 t/d August, rel. stdev: 0.60
maximum: 52.6 t/d January, rel. stdev: 0.52



## Phosphate load for Nieuwe Waterweg

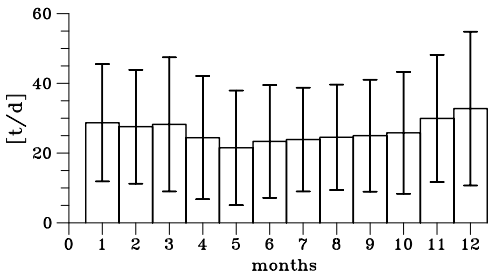
ANNUAL LOADS

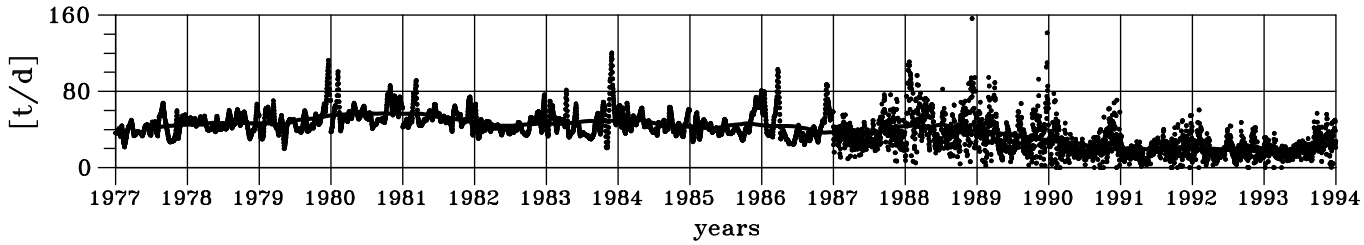
| year | kt/y | year | kt/y | year | kt/y | year | kt/y | year | kt/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 14.9 | 1984 | 17.1 | 1991 | 6.6 | 1998 | 4.6 | 2005 | 3.2 |
| 1978 | 17.1 | 1985 | 15.9 | 1992 | 6.8 | 1999 | 5.2 | 2006 | 3.3 |
| 1979 | 17.9 | 1986 | 15.7 | 1993 | 7.7 | 2000 | 5.4 | 2007 | 4.0 |
| 1980 | 21.0 | 1987 | 12.5 | 1994 | 7.7 | 2001 | 3.0 | 2008 | 3.7 |
| 1981 | 19.5 | 1988 | 16.8 | 1995 | 7.2 | 2002 | 4.4 | 2009 | 3.3 |
| 1982 | 16.0 | 1989 | 12.6 | 1996 | 6.0 | 2003 | 2.7 | | |
| 1983 | 17.6 | 1990 | 8.7 | 1997 | 5.7 | 2004 | 3.3 | | |

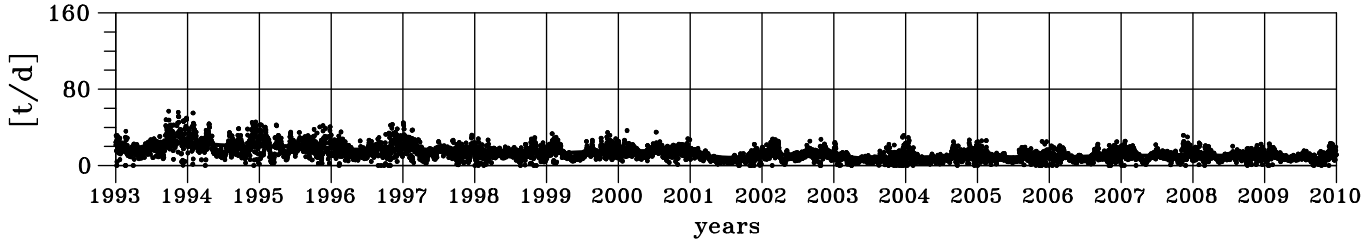
TIME SERIES
mean: 26.3 t/d
relative standard deviation: 0.72
minimum: 0.0 t/d February 8, 1990
maximum: 156.4 t/d December 7, 1988

LOW PASS
minimum: 7.4 t/d June 2003
maximum: 58.3 t/d May 1980

ANNUAL CYCLE
minimum: 21.5 t/d May, rel. stdev: 0.76
maximum: 32.7 t/d December, rel. stdev: 0.67



## Silicate load for Nieuwe Waterweg

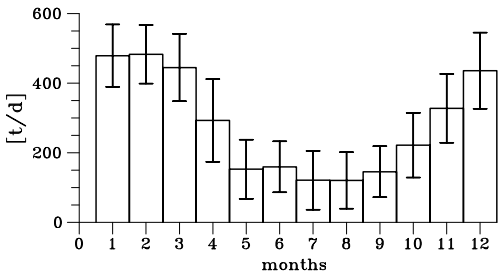
ANNUAL LOADS

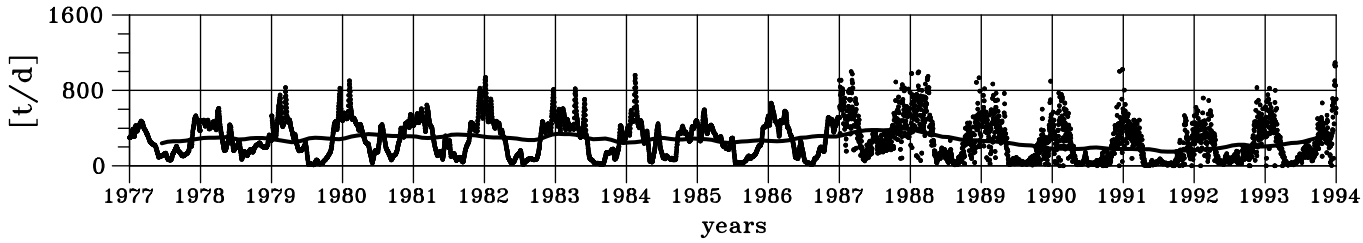
| year | kt/y | year | kt/y | year | kt/y | year | kt/y | year | kt/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 90.2 | 1984 | 108.7 | 1991 | 57.3 | | | 2005 | 100.5 |
| 1978 | 102.6 | 1985 | 88.0 | 1992 | 77.2 | 1999 | 104.8 | 2006 | 106.0 |
| 1979 | 103.3 | 1986 | 108.8 | 1993 | 90.1 | 2000 | 118.2 | 2007 | 132.2 |
| 1980 | 120.1 | 1987 | 139.9 | 1994 | 107.2 | 2001 | 111.1 | 2008 | 125.3 |
| 1981 | 116.7 | 1988 | 112.2 | | | 2002 | 130.8 | 2009 | 107.7 |
| 1982 | 103.8 | 1989 | 84.2 | | | 2003 | 63.9 | | |
| 1983 | 103.5 | 1990 | 67.3 | | | 2004 | 95.8 | | |

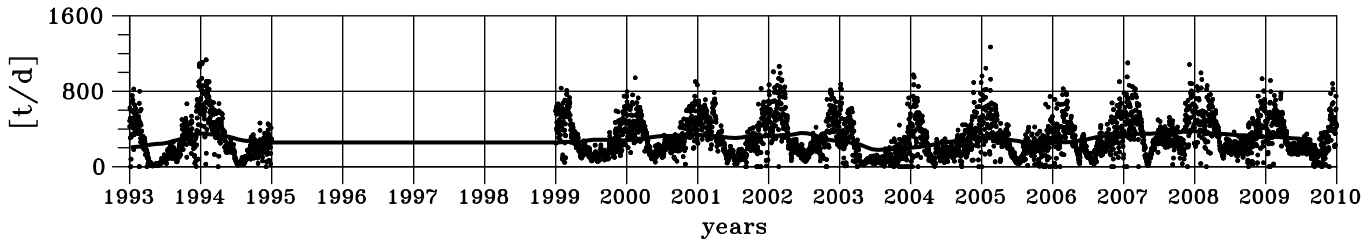
TIME SERIES
mean: 279.9 t/d
relative standard deviation: 0.66
minimum: 0.0 t/d February 8, 1990
maximum: 1268.8 t/d February 15, 2005

LOW PASS
minimum: 151.9 t/d August 1991
maximum: 395.5 t/d November 1987

ANNUAL CYCLE
minimum: 120.5 t/d August, rel. stdev: 0.67
maximum: 483.0 t/d February, rel. stdev: 0.17



## Total Alkalinity load for Nieuwe Waterweg

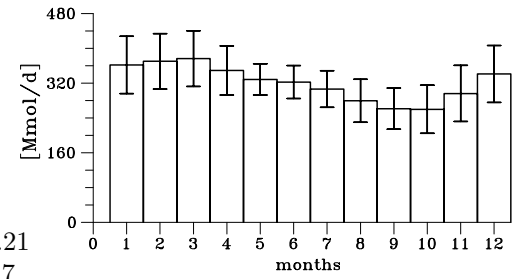
ANNUAL LOADS

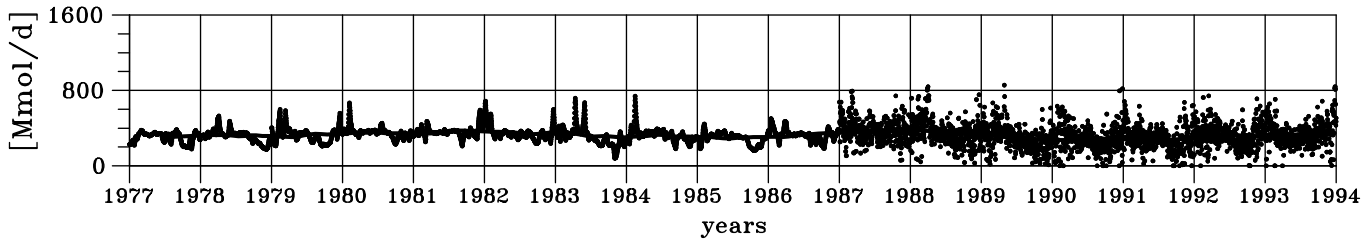
| year | Gmol/y | year | Gmol/y | year | Gmol/y | year | Gmol/y | year | Gmol/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 110.3 | 1984 | 120.1 | 1991 | 102.6 | 1998 | 86.9 | 2005 | 107.3 |
| 1978 | 115.1 | 1985 | 105.8 | 1992 | 115.0 | 1999 | 121.9 | 2006 | 114.1 |
| 1979 | 120.1 | 1986 | 119.8 | 1993 | 121.7 | 2000 | 122.1 | 2007 | 127.9 |
| 1980 | 128.7 | 1987 | 137.6 | 1994 | 129.9 | 2001 | 129.9 | 2008 | 128.4 |
| 1981 | 131.8 | 1988 | 131.0 | 1995 | 128.3 | 2002 | 132.4 | 2009 | 115.3 |
| 1982 | 126.9 | 1989 | 107.1 | 1996 | 103.9 | 2003 | 89.6 | | |
| 1983 | 113.3 | 1990 | 102.7 | 1997 | 109.5 | 2004 | 110.7 | | |

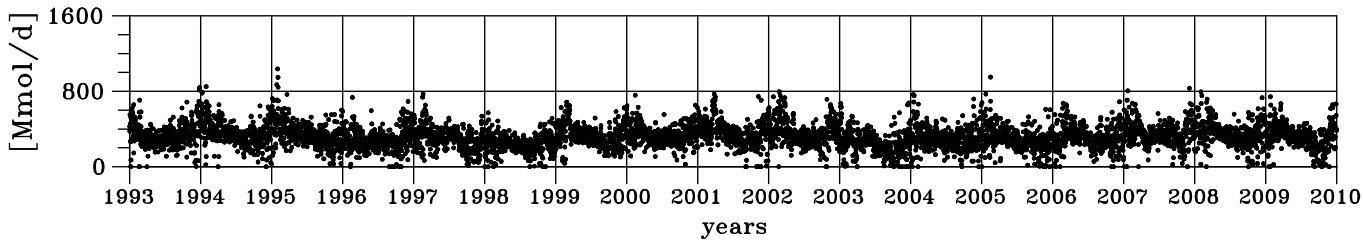
TIME SERIES
mean: 320.9 Mmol/d
relative standard deviation: 0.36
minimum: 0.0 Mmol/d February 8, 1990
maximum: 1036.3 Mmold January 31, 1995

LOW PASS
minimum: 231.2 Mmol/d April 1998
maximum: 387.5 Mmol/d November 1987

ANNUAL CYCLE
minimum: 259.8 Mmol/d October, rel. stdev: 0.21
maximum: 376.5 Mmol/d March, rel. stdev: 0.17



## Dissolved Inorganic Carbon load for Nieuwe Waterweg

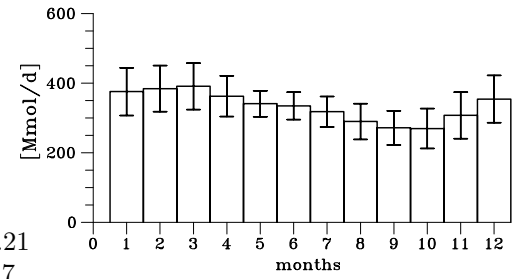
ANNUAL LOADS

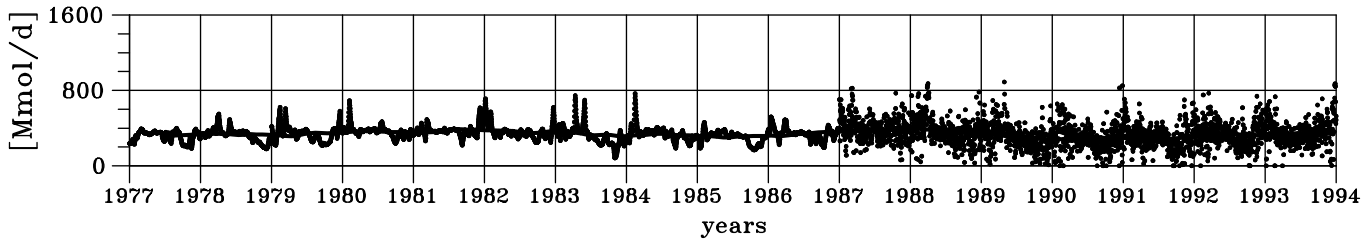
| year | Gmol/y | year | Gmol/y | year | Gmol/y | year | Gmol/y | year | Gmol/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 114.5 | 1984 | 124.6 | 1991 | 106.5 | 1998 | 90.2 | 2005 | 111.4 |
| 1978 | 119.4 | 1985 | 109.8 | 1992 | 119.3 | 1999 | 126.6 | 2006 | 118.4 |
| 1979 | 124.6 | 1986 | 124.3 | 1993 | 126.3 | 2000 | 126.8 | 2007 | 132.8 |
| 1980 | 133.6 | 1987 | 142.8 | 1994 | 134.8 | 2001 | 134.9 | 2008 | 133.2 |
| 1981 | 136.8 | 1988 | 136.0 | 1995 | 133.2 | 2002 | 137.5 | 2009 | 119.7 |
| 1982 | 131.7 | 1989 | 111.2 | 1996 | 107.8 | 2003 | 93.0 | | |
| 1983 | 117.6 | 1990 | 106.6 | 1997 | 113.7 | 2004 | 114.9 | | |

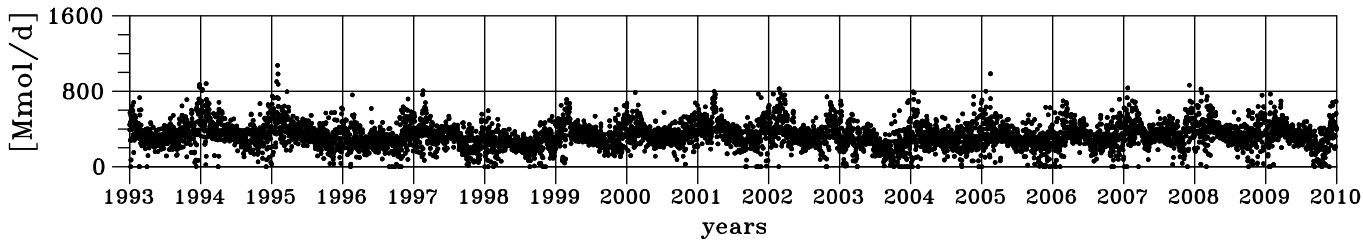
TIME SERIES
mean: 333.1 Mmol/d
relative standard deviation: 0.36
minimum: 0.0 Mmol/d February 8, 1990
maximum: 1075.7 Mmold January 31, 1995

LOW PASS
minimum: 240.0 Mmol/d April 1998
maximum: 402.2 Mmol/d November 1987

ANNUAL CYCLE
minimum: 269.7 Mmol/d October, rel. stdev: 0.21
maximum: 390.8 Mmol/d March, rel. stdev: 0.17



## Dissolved Organic Carbon load for Nieuwe Waterweg

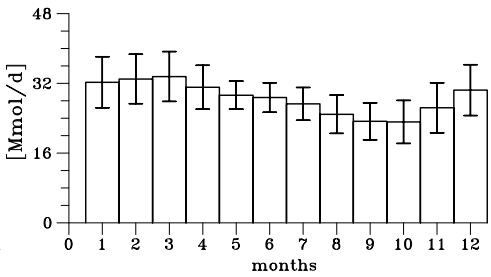
ANNUAL LOADS

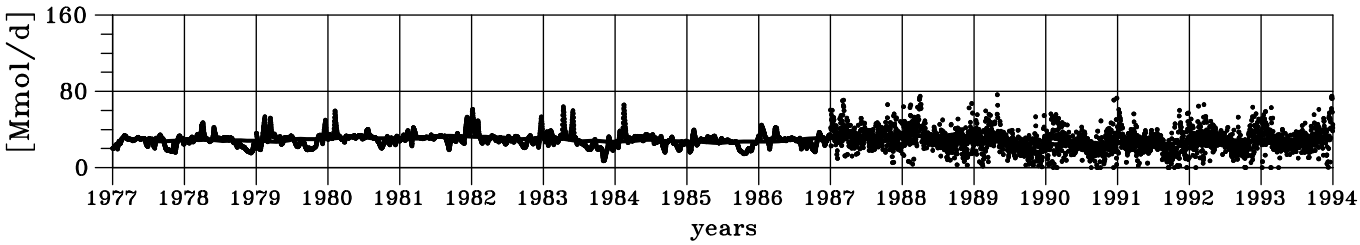
| year | Gmol/y | year | Gmol/y | year | Gmol/y | year | Gmol/y | year | Gmol/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 9.8 | 1984 | 10.7 | 1991 | 9.1 | 1998 | 7.7 | 2005 | 9.6 |
| 1978 | 10.3 | 1985 | 9.4 | 1992 | 10.2 | 1999 | 10.9 | 2006 | 10.2 |
| 1979 | 10.7 | 1986 | 10.7 | 1993 | 10.8 | 2000 | 10.9 | 2007 | 11.4 |
| 1980 | 11.5 | 1987 | 12.3 | 1994 | 11.6 | 2001 | 11.6 | 2008 | 11.4 |
| 1981 | 11.8 | 1988 | 11.7 | 1995 | 11.4 | 2002 | 11.8 | 2009 | 10.3 |
| 1982 | 11.3 | 1989 | 9.5 | 1996 | 9.3 | 2003 | 8.0 | | |
| 1983 | 10.1 | 1990 | 9.2 | 1997 | 9.8 | 2004 | 9.9 | | |

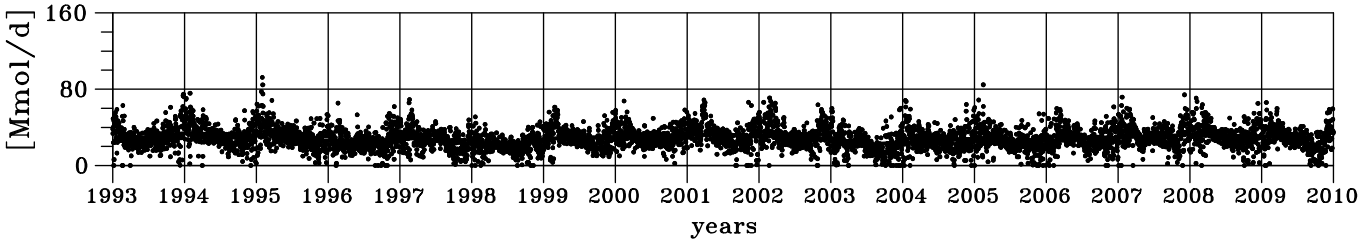
TIME SERIES
mean: 28.6 Mmol/d
relative standard deviation: 0.36
minimum: 0.0 Mmol/d February 8, 1990
maximum: 92.4 Mmold January 31, 1995

LOW PASS
minimum: 20.6 Mmol/d April 1998
maximum: 34.5 Mmol/d November 1987

ANNUAL CYCLE
minimum: 23.2 Mmol/d October, rel. stdev: 0.21
maximum: 33.6 Mmol/d March, rel. stdev: 0.17



## 5.7 Loads of Haringvliet

### Total Nitrogen load for Haringvliet

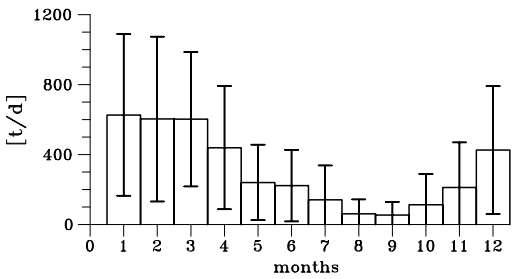
ANNUAL LOADS

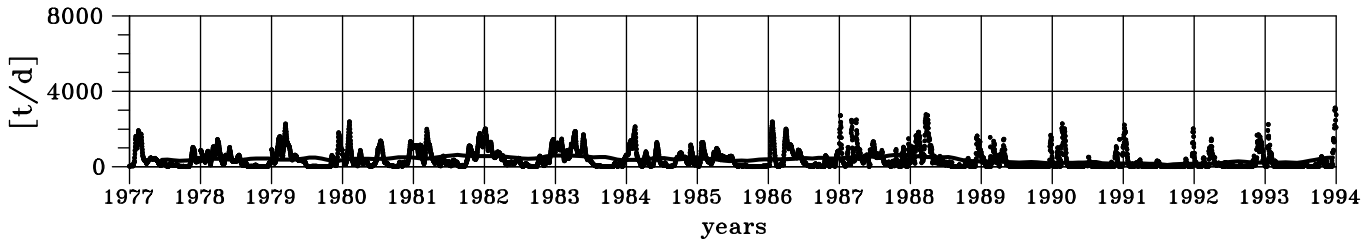
| year | kt/y | year | kt/y | year | kt/y | year | kt/y | year | kt/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 129.5 | 1984 | 168.8 | 1991 | 62.8 | 1998 | 97.8 | 2005 | 44.7 |
| 1978 | 128.1 | 1985 | 103.9 | 1992 | 89.9 | 1999 | 114.1 | 2006 | 60.9 |
| 1979 | 173.3 | 1986 | 169.1 | 1993 | 77.9 | 2000 | 99.9 | 2007 | 81.0 |
| 1980 | 146.8 | 1987 | 191.9 | 1994 | 146.7 | 2001 | 113.1 | 2008 | 53.6 |
| 1981 | 213.6 | 1988 | 192.6 | 1995 | 197.4 | 2002 | 128.5 | 2009 | 37.2 |
| 1982 | 164.5 | 1989 | 78.9 | 1996 | 44.6 | 2003 | 81.2 | | |
| 1983 | 181.9 | 1990 | 74.8 | 1997 | 49.4 | 2004 | 42.3 | | |

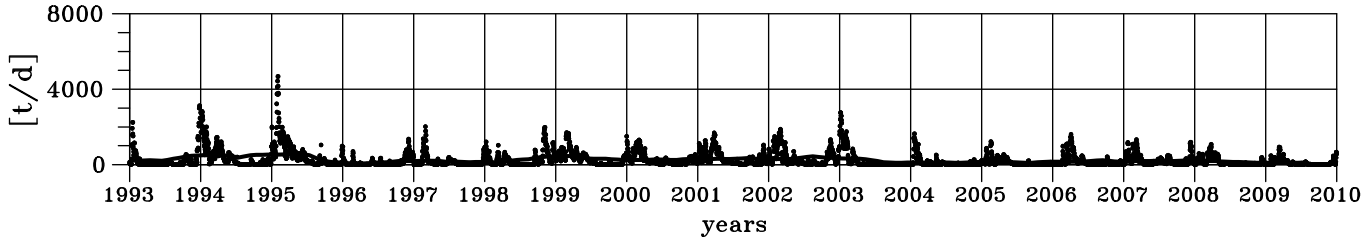
TIME SERIES
mean: 310.4 t/d
relative standard deviation: 1.43
minimum: 0.0 t/d August 28, 1990
maximum: 4672.3 t/d February 2, 1995

LOW PASS
minimum: 61.4 t/d April 1996
maximum: 641.4 t/d November 1987

ANNUAL CYCLE
minimum: 54.4 t/d September, rel. stdev: 1.38
maximum: 626.5 t/d January, rel. stdev: 0.74



## Nitrate + Nitrite load for Haringvliet

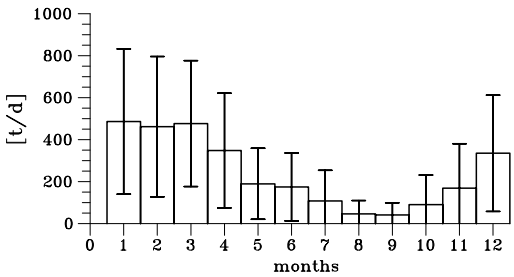
ANNUAL LOADS

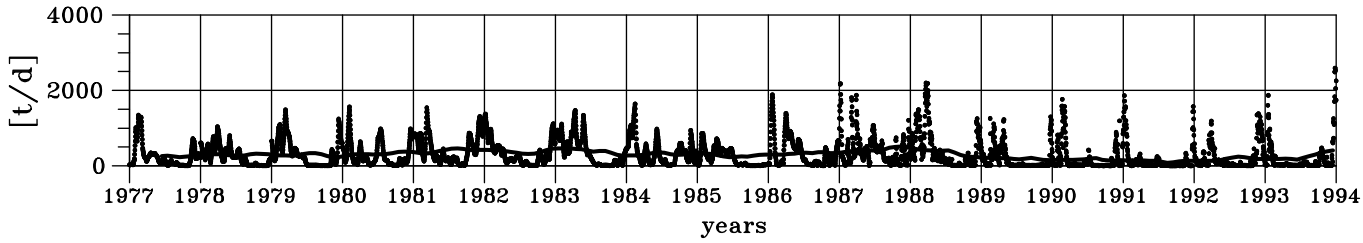
| year | kt/y | year | kt/y | year | kt/y | year | kt/y | year | kt/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 92.0 | 1984 | 131.6 | 1991 | 51.4 | 1998 | 84.3 | 2005 | 35.5 |
| 1978 | 94.3 | 1985 | 75.9 | 1992 | 73.7 | 1999 | 97.8 | 2006 | 48.4 |
| 1979 | 122.3 | 1986 | 130.5 | 1993 | 65.0 | 2000 | 84.6 | 2007 | 70.1 |
| 1980 | 107.0 | 1987 | 150.0 | 1994 | 120.0 | 2001 | 97.0 | 2008 | 46.9 |
| 1981 | 162.5 | 1988 | 152.4 | 1995 | 142.3 | 2002 | 106.0 | 2009 | 30.7 |
| 1982 | 120.6 | 1989 | 62.6 | 1996 | 38.0 | 2003 | 58.3 | | |
| 1983 | 139.7 | 1990 | 59.3 | 1997 | 42.4 | 2004 | 34.3 | | |

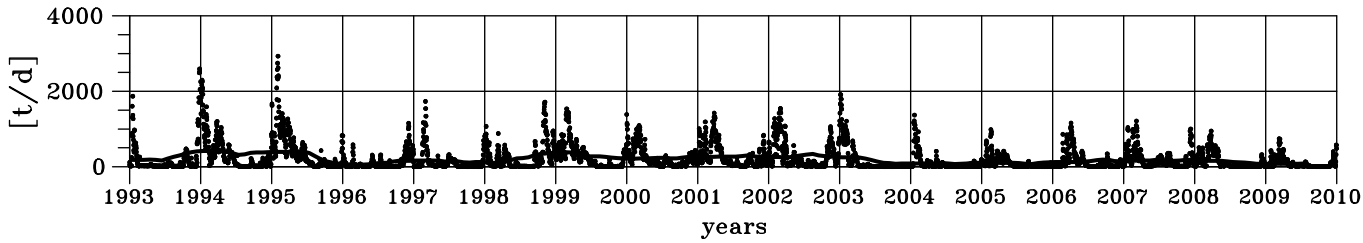
TIME SERIES
mean: 242.9 t/d
relative standard deviation: 1.41
minimum: 0.0 t/d August 28, 1990
maximum: 2927.3 t/d February 2, 1995

LOW PASS
minimum: 52.3 t/d April 1996
maximum: 513.0 t/d November 1987

ANNUAL CYCLE
minimum: 41.2 t/d September, rel. stdev: 1.41
maximum: 486.2 t/d January, rel. stdev: 0.71



## Ammonium load for Haringvliet

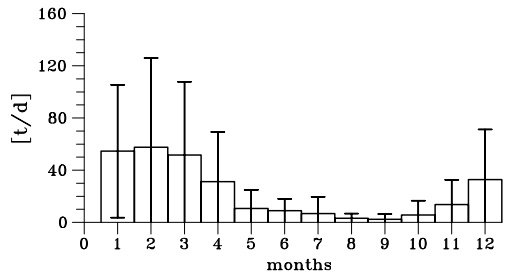
ANNUAL LOADS

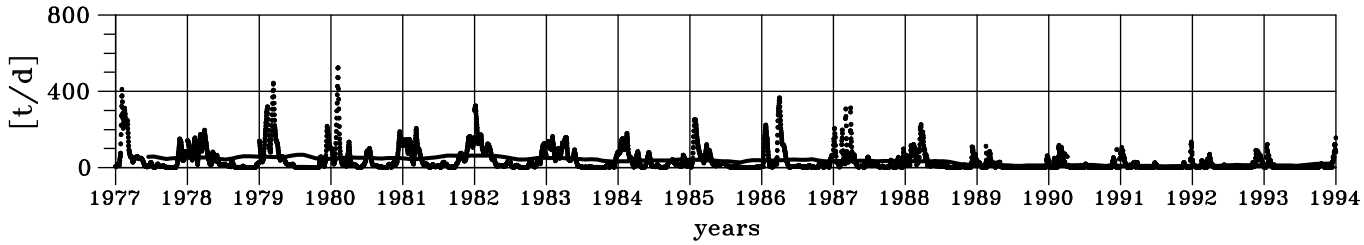
| year | t/y | year | t/y | year | t/y | year | t/y | year | t/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 19944 | 1984 | 13617 | 1991 | 3693 | 1998 | 3824 | 2005 | 1045 |
| 1978 | 15312 | 1985 | 11813 | 1992 | 4311 | 1999 | 3669 | 2006 | 1674 |
| 1979 | 24225 | 1986 | 15603 | 1993 | 3332 | 2000 | 3072 | 2007 | 1358 |
| 1980 | 18596 | 1987 | 12901 | 1994 | 6158 | 2001 | 3663 | 2008 | 1921 |
| 1981 | 19828 | 1988 | 12466 | | | 2002 | 4207 | 2009 | 992 |
| 1982 | 18746 | 1989 | 3256 | | | 2003 | 2575 | | |
| 1983 | 15377 | 1990 | 4473 | | | 2004 | 1291 | | |

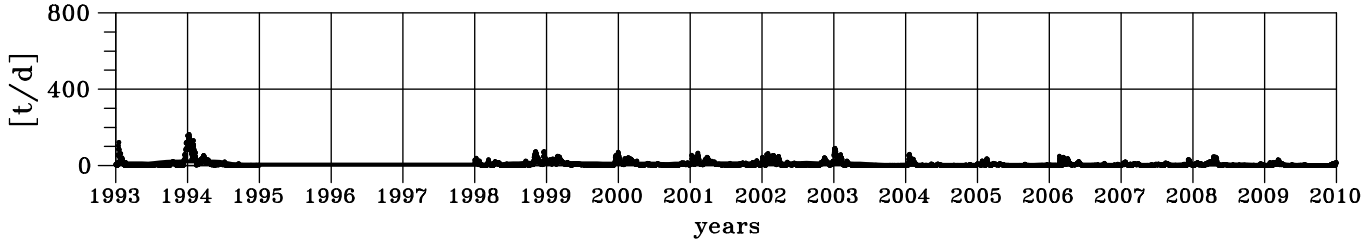
TIME SERIES
mean: 24.1 t/d
relative standard deviation: 1.83
minimum: 0.0 t/d August 28, 1990
maximum: 523.7 t/d February 6, 1980

LOW PASS
minimum: 2.2 t/d August 2005
maximum: 67.7 t/d August 1979

ANNUAL CYCLE
minimum: 2.3 t/d September, rel. stdev: 1.78
maximum: 57.6 t/d February, rel. stdev: 1.19



## Total Phosphorus load for Haringvliet

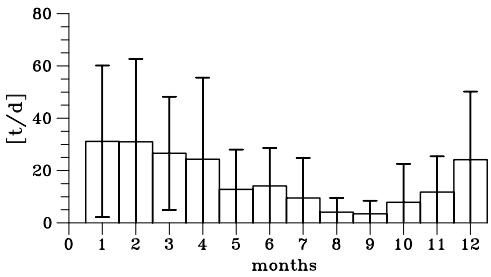
ANNUAL LOADS

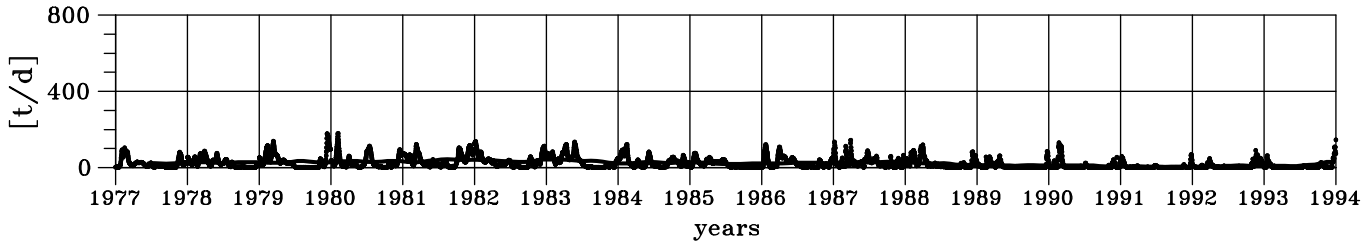
| year | kt/y | year | kt/y | year | kt/y | year | kt/y | year | kt/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 7.9 | 1984 | 10.7 | 1991 | 1.9 | 1998 | 3.5 | 2005 | 1.5 |
| 1978 | 8.6 | 1985 | 6.4 | 1992 | 3.4 | 1999 | 4.2 | 2006 | 2.2 |
| 1979 | 12.5 | 1986 | 9.5 | 1993 | 2.7 | 2000 | 3.9 | 2007 | 2.9 |
| 1980 | 10.9 | 1987 | 10.0 | 1994 | 10.2 | 2001 | 3.5 | 2008 | 2.8 |
| 1981 | 14.6 | 1988 | 8.6 | 1995 | 10.7 | 2002 | 5.5 | 2009 | 1.4 |
| 1982 | 11.7 | 1989 | 3.4 | 1996 | 1.6 | 2003 | 3.8 | | |
| 1983 | 12.4 | 1990 | 3.6 | 1997 | 1.9 | 2004 | 2.3 | | |

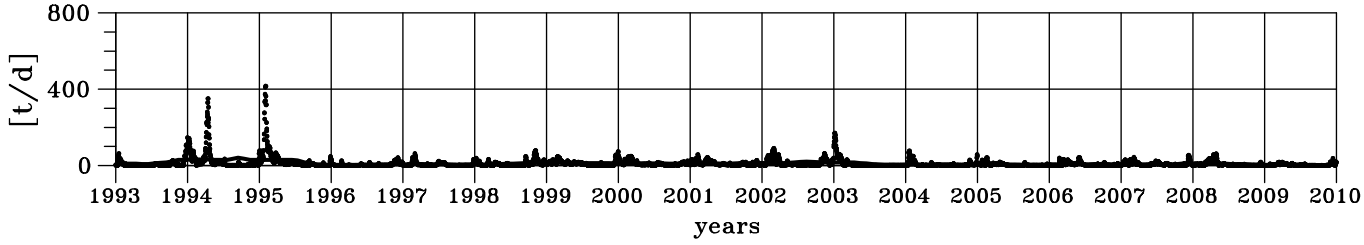
TIME SERIES
mean: 16.7 t/d
relative standard deviation: 1.64
minimum: 0.0 t/d August 28, 1990
maximum: 416.2 t/d February 2, 1995

LOW PASS
minimum: 2.5 t/d April 1996
maximum: 42.9 t/d August 1981

ANNUAL CYCLE
minimum: 3.4 t/d September, rel. stdev: 1.47
maximum: 31.2 t/d January, rel. stdev: 0.93



## Phosphate load for Haringvliet

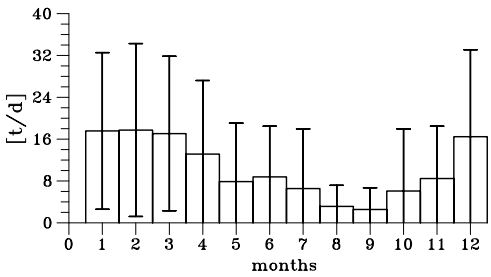
ANNUAL LOADS

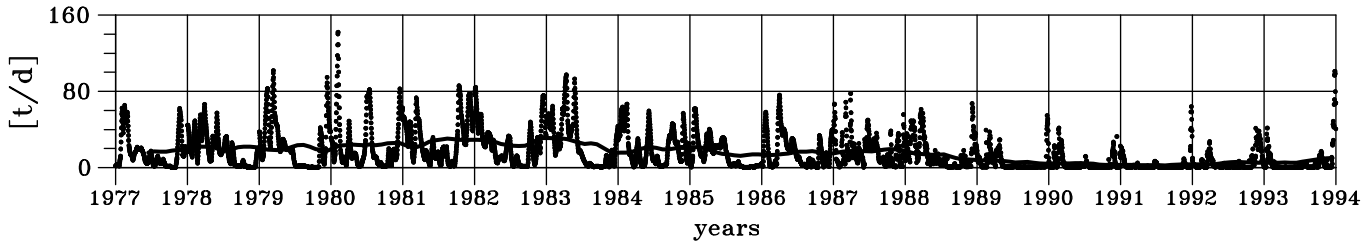
| year | t/y | year | t/y | year | t/y | year | t/y | year | t/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 5734 | 1984 | 7824 | 1991 | 1052 | 1998 | 2252 | 2005 | 953 |
| 1978 | 6850 | 1985 | 4966 | 1992 | 1893 | 1999 | 2511 | 2006 | 1088 |
| 1979 | 8430 | 1986 | 6156 | 1993 | 2125 | 2000 | 2537 | 2007 | 1986 |
| 1980 | 8631 | 1987 | 6252 | 1994 | 2519 | 2001 | 2137 | 2008 | 1193 |
| 1981 | 10579 | 1988 | 5213 | 1995 | 3183 | 2002 | 3021 | 2009 | 816 |
| 1982 | 8597 | 1989 | 2025 | 1996 | 1035 | 2003 | 1385 | | |
| 1983 | 9077 | 1990 | 1487 | 1997 | 1241 | 2004 | 884 | | |

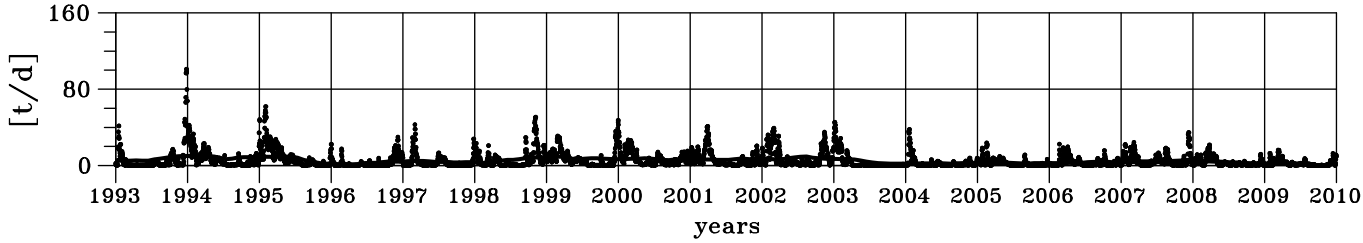
TIME SERIES
mean: 10.4 t/d
relative standard deviation: 1.50
minimum: 0.0 t/d August 28, 1990
maximum: 141.9 t/d February 6, 1980

LOW PASS
minimum: 1.3 t/d April 1996
maximum: 31.1 t/d December 1982

ANNUAL CYCLE
minimum: 2.5 t/d September, rel. stdev: 1.63
maximum: 17.7 t/d February, rel. stdev: 0.93



## Silicate load for Haringvliet

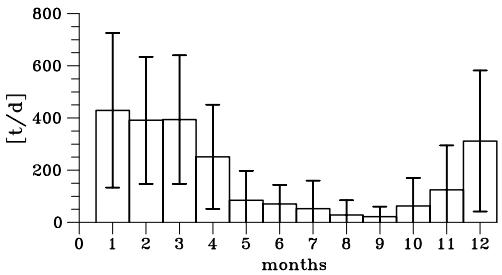
ANNUAL LOADS

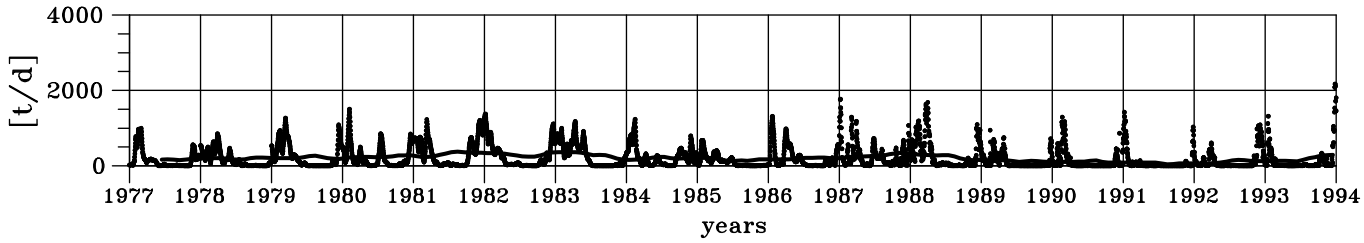
| year | kt/y | year | kt/y | year | kt/y | year | kt/y | year | kt/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 59.1 | 1984 | 88.2 | 1991 | 32.4 | | | 2005 | 33.5 |
| 1978 | 60.7 | 1985 | 42.2 | 1992 | 46.3 | 1999 | 78.5 | 2006 | 37.6 |
| 1979 | 92.0 | 1986 | 77.1 | 1993 | 47.4 | 2000 | 72.1 | 2007 | 71.8 |
| 1980 | 81.7 | 1987 | 94.0 | 1994 | 76.8 | 2001 | 82.2 | 2008 | 45.9 |
| 1981 | 127.0 | 1988 | 107.7 | | | 2002 | 104.6 | 2009 | 30.7 |
| 1982 | 94.4 | 1989 | 38.6 | | | 2003 | 56.9 | | |
| 1983 | 105.1 | 1990 | 39.2 | | | 2004 | 28.5 | | |

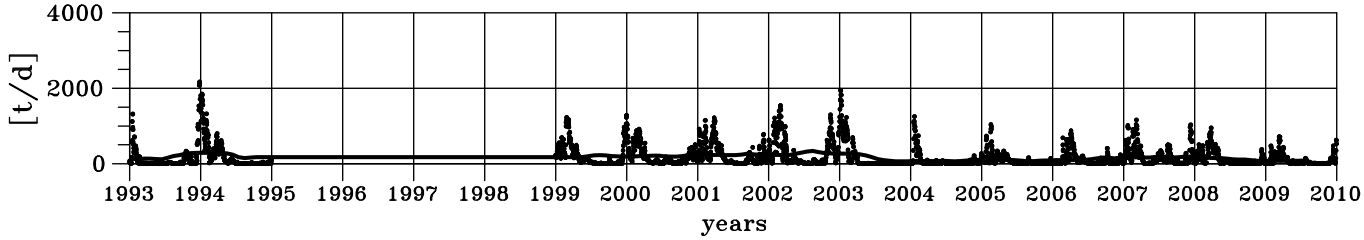
TIME SERIES
mean: 186.1 t/d
relative standard deviation: 1.44
minimum: 0.0 t/d August 28, 1990
maximum: 2168.6 t/d December 27, 1993

LOW PASS
minimum: 38.6 t/d August 1991
maximum: 374.8 t/d August 1981

ANNUAL CYCLE
minimum: 21.6 t/d September, rel. stdev: 1.79
maximum: 429.4 t/d January, rel. stdev: 0.69



## Total Alkalinity load for Haringvliet

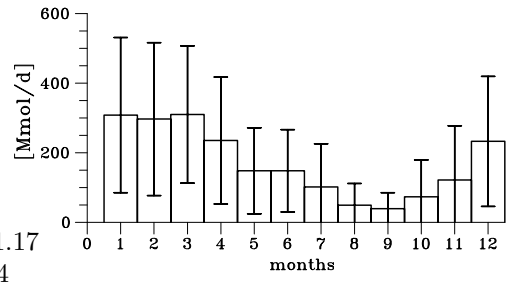
ANNUAL LOADS

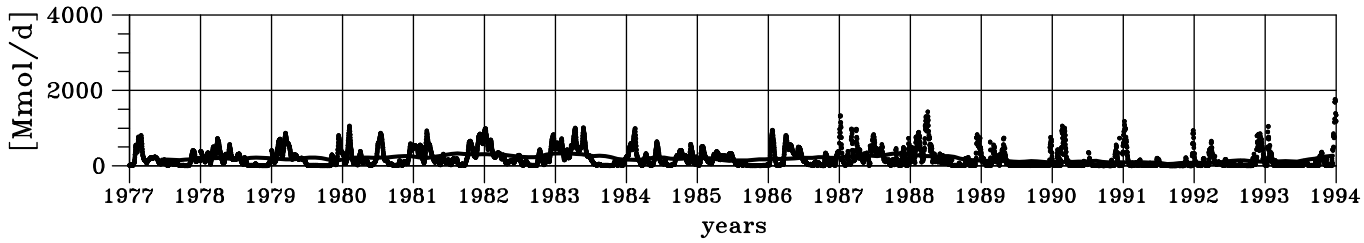
| year | Gmol/y | year | Gmol/y | year | Gmol/y | year | Gmol/y | year | Gmol/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 58.2 | 1984 | 81.2 | 1991 | 32.9 | 1998 | 55.7 | 2005 | 31.9 |
| 1978 | 65.2 | 1985 | 46.7 | 1992 | 45.7 | 1999 | 82.6 | 2006 | 41.3 |
| 1979 | 79.1 | 1986 | 78.8 | 1993 | 43.6 | 2000 | 66.1 | 2007 | 61.9 |
| 1980 | 75.8 | 1987 | 98.1 | 1994 | 78.5 | 2001 | 85.4 | 2008 | 40.5 |
| 1981 | 111.6 | 1988 | 97.5 | 1995 | 101.3 | 2002 | 90.8 | 2009 | 28.5 |
| 1982 | 88.3 | 1989 | 36.5 | 1996 | 25.0 | 2003 | 46.2 | | |
| 1983 | 96.2 | 1990 | 38.4 | 1997 | 30.8 | 2004 | 27.8 | | |

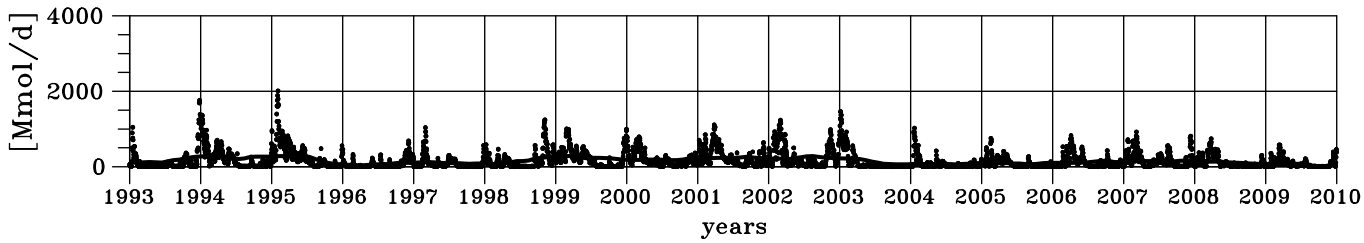
TIME SERIES
mean: 171.6 Mmol/d
relative standard deviation: 1.32
minimum: 0.0 Mmol/d August 28, 1990
maximum: 2009.6 Mmold February 2, 1995

LOW PASS
minimum: 37.3 Mmol/d April 1996
maximum: 336.5 Mmol/d November 1987

ANNUAL CYCLE
minimum: 39.3 Mmol/d September, rel. stdev: 1.17
maximum: 310.2 Mmol/d March, rel. stdev: 0.64



## Dissolved Inorganic Carbon load for Haringvliet

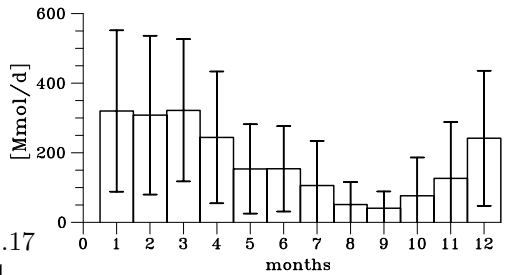
ANNUAL LOADS

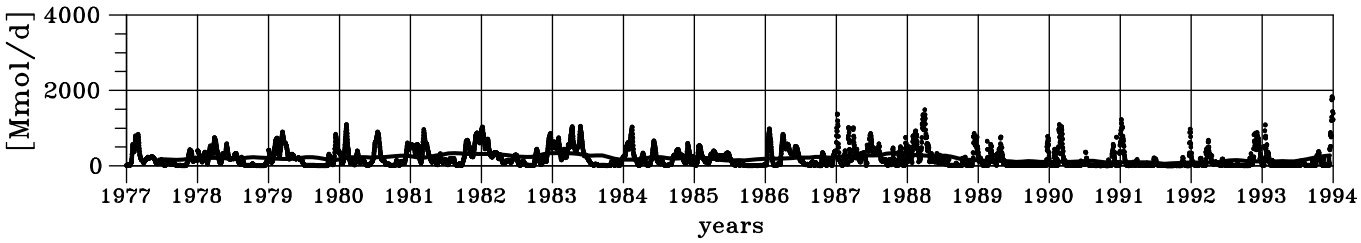
| year | Gmol/y | year | Gmol/y | year | Gmol/y | year | Gmol/y | year | Gmol/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 60.4 | 1984 | 84.2 | 1991 | 34.2 | 1998 | 57.8 | 2005 | 33.1 |
| 1978 | 67.7 | 1985 | 48.5 | 1992 | 47.4 | 1999 | 85.7 | 2006 | 42.9 |
| 1979 | 82.1 | 1986 | 81.8 | 1993 | 45.3 | 2000 | 68.6 | 2007 | 64.3 |
| 1980 | 78.6 | 1987 | 101.9 | 1994 | 81.5 | 2001 | 88.6 | 2008 | 42.0 |
| 1981 | 115.8 | 1988 | 101.2 | 1995 | 105.2 | 2002 | 94.2 | 2009 | 29.6 |
| 1982 | 91.7 | 1989 | 37.9 | 1996 | 26.0 | 2003 | 48.0 | | |
| 1983 | 99.9 | 1990 | 39.8 | 1997 | 32.0 | 2004 | 28.8 | | |

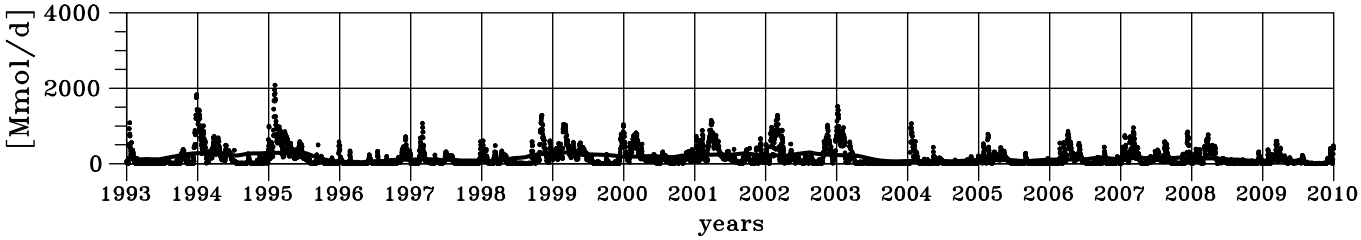
TIME SERIES
mean: 178.1 Mmol/d
relative standard deviation: 1.32
minimum: 0.0 Mmol/d August 28, 1990
maximum: 2085.9 Mmold February 2, 1995

LOW PASS
minimum: 38.8 Mmol/d April 1996
maximum: 349.3 Mmol/d November 1987

ANNUAL CYCLE
minimum: 40.8 Mmol/d September, rel. stdev: 1.17
maximum: 322.0 Mmol/d March, rel. stdev: 0.64



## Dissolved Organic Carbon load for Haringvliet

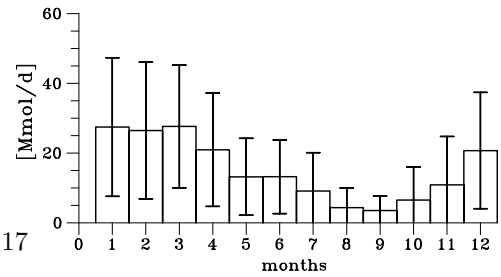
ANNUAL LOADS

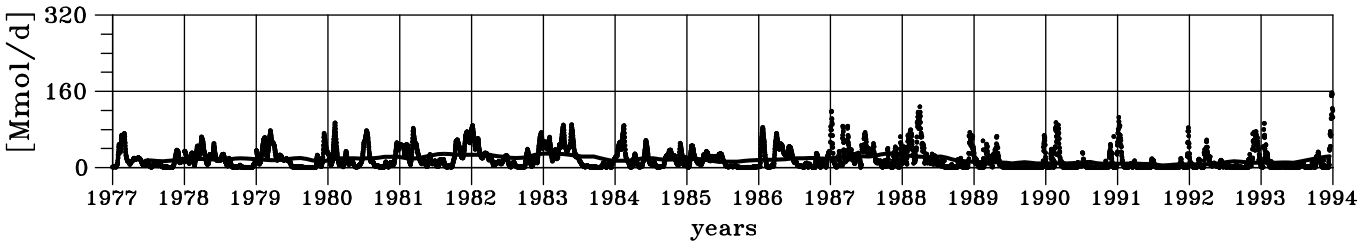
| year | Gmol/y | year | Gmol/y | year | Gmol/y | year | Gmol/y | year | Gmol/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 5.2 | 1984 | 7.2 | 1991 | 2.9 | 1998 | 5.0 | 2005 | 2.8 |
| 1978 | 5.8 | 1985 | 4.2 | 1992 | 4.1 | 1999 | 7.4 | 2006 | 3.7 |
| 1979 | 7.0 | 1986 | 7.0 | 1993 | 3.9 | 2000 | 5.9 | 2007 | 5.5 |
| 1980 | 6.8 | 1987 | 8.7 | 1994 | 7.0 | 2001 | 7.6 | 2008 | 3.6 |
| 1981 | 9.9 | 1988 | 8.7 | 1995 | 9.0 | 2002 | 8.1 | 2009 | 2.5 |
| 1982 | 7.9 | 1989 | 3.3 | 1996 | 2.2 | 2003 | 4.1 | | |
| 1983 | 8.6 | 1990 | 3.4 | 1997 | 2.7 | 2004 | 2.5 | | |

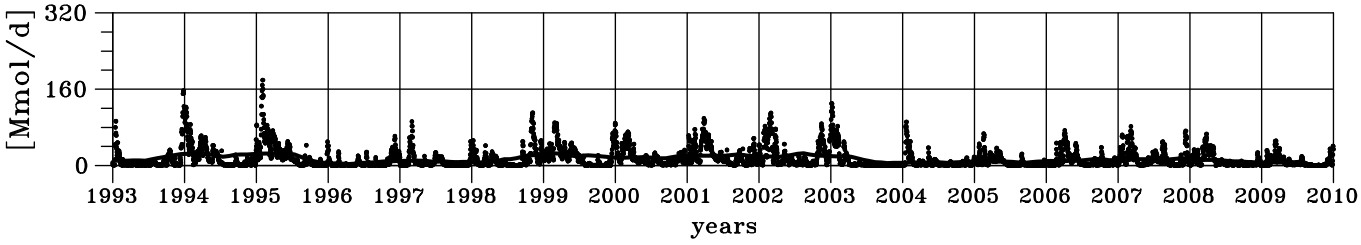
TIME SERIES
mean: 15.3 Mmol/d
relative standard deviation: 1.32
minimum: 0.0 Mmol/d August 28, 1990
maximum: 179.1 Mmold February 2, 1995

LOW PASS
minimum: 3.3 Mmol/d April 1996
maximum: 30.0 Mmol/d November 1987

ANNUAL CYCLE
minimum: 3.5 Mmol/d September, rel. stdev: 1.17
maximum: 27.7 Mmol/d March, rel. stdev: 0.64



## 5.8 Loads of River Schelde

### Total Nitrogen load for River Schelde

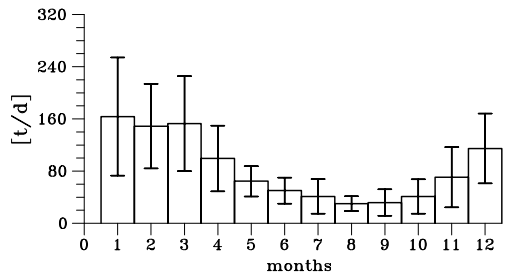
ANNUAL LOADS

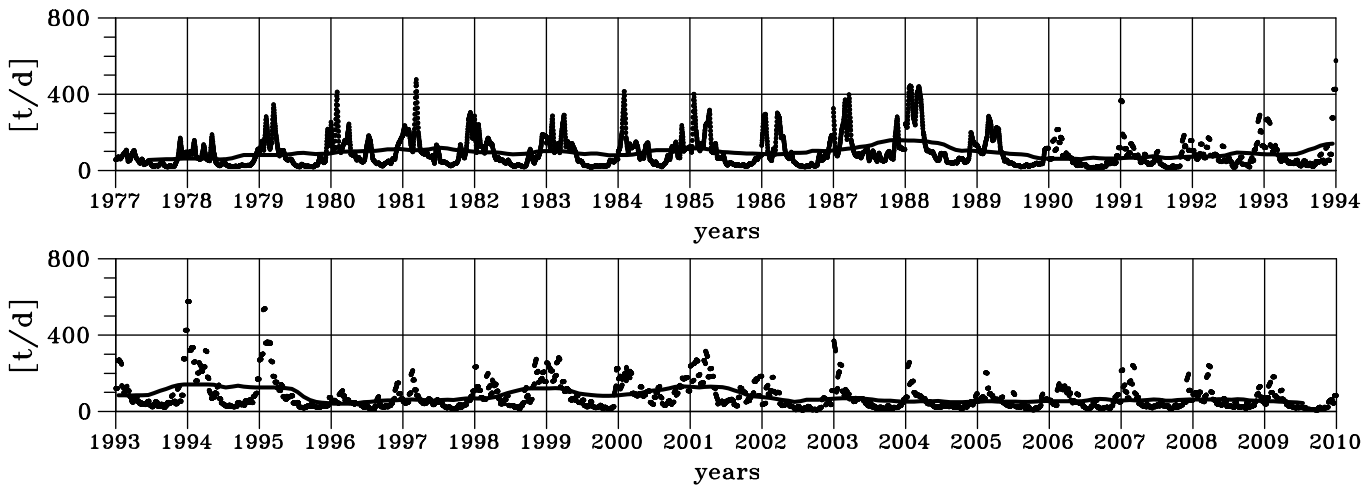
| year | kt/y | year | kt/y | year | kt/y | year | kt/y | year | kt/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 20.2 | 1984 | 38.7 | 1991 | 27.9 | 1998 | 36.4 | 2005 | 19.0 |
| 1978 | 20.9 | 1985 | 34.5 | 1992 | 30.0 | 1999 | 33.3 | 2006 | 19.6 |
| 1979 | 32.1 | 1986 | 35.1 | 1993 | 32.2 | 2000 | 39.9 | 2007 | 23.2 |
| 1980 | 37.5 | 1987 | 45.5 | 1994 | 45.8 | 2001 | 45.8 | 2008 | 22.7 |
| 1981 | 44.1 | 1988 | 53.6 | 1995 | 41.5 | 2002 | 17.1 | 2009 | 16.4 |
| 1982 | 31.2 | 1989 | 31.1 | 1996 | 18.3 | 2003 | 23.5 | | |
| 1983 | 30.8 | 1990 | 21.4 | 1997 | 20.1 | 2004 | 20.0 | | |

TIME SERIES
mean: 83.8 t/d
relative standard deviation: 0.89
minimum: 7.1 t/d July 31, 2002
maximum: 576.1 t/d January 1, 1994

LOW PASS
minimum: 40.4 t/d February 1996
maximum: 160.1 t/d November 1987

ANNUAL CYCLE
minimum: 30.0 t/d August, rel. stdev: 0.37
maximum: 163.5 t/d January, rel. stdev: 0.55



## Nitrate + Nitrite load for River Schelde

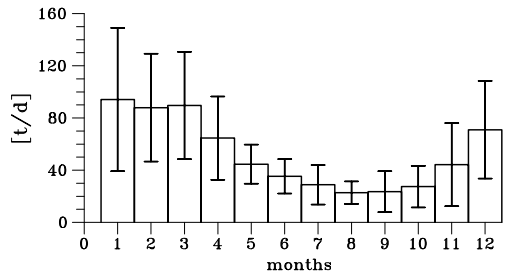
ANNUAL LOADS

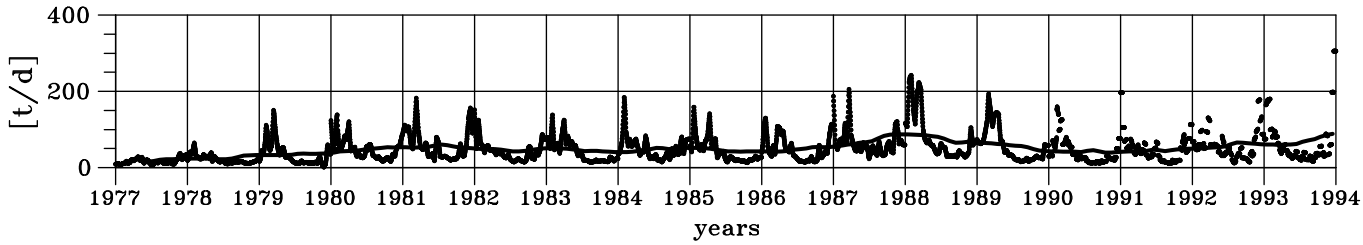
| year | kt/y | year | kt/y | year | kt/y | year | kt/y | year | kt/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 6.1 | 1984 | 18.5 | 1991 | 17.5 | 1998 | 28.6 | 2005 | 15.3 |
| 1978 | 7.7 | 1985 | 15.5 | 1992 | 21.1 | 1999 | 24.5 | 2006 | 15.7 |
| 1979 | 12.4 | 1986 | 18.1 | 1993 | 23.5 | 2000 | 31.9 | 2007 | 19.2 |
| 1980 | 17.6 | 1987 | 23.8 | 1994 | 29.1 | 2001 | 36.3 | 2008 | 19.0 |
| 1981 | 22.2 | 1988 | 29.4 | 1995 | 28.5 | 2002 | 12.4 | 2009 | 13.0 |
| 1982 | 15.6 | 1989 | 21.2 | 1996 | 13.2 | 2003 | 17.3 | | |
| 1983 | 15.6 | 1990 | 14.7 | 1997 | 14.8 | 2004 | 15.7 | | |

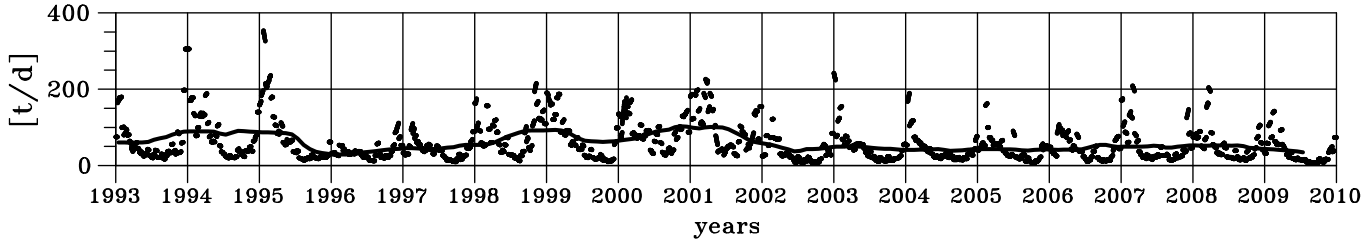
TIME SERIES
mean: 52.7 t/d
relative standard deviation: 0.83
minimum: 1.0 t/d November 26, 1979
maximum: 353.1 t/d January 23, 1995

LOW PASS
minimum: 16.2 t/d June 1977
maximum: 102.7 t/d November 2000

ANNUAL CYCLE
minimum: 22.8 t/d August, rel. stdev: 0.38
maximum: 94.2 t/d January, rel. stdev: 0.58



## Ammonium load for River Schelde

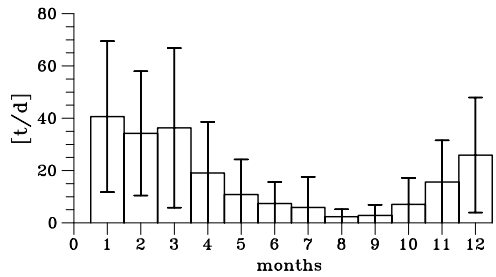
ANNUAL LOADS

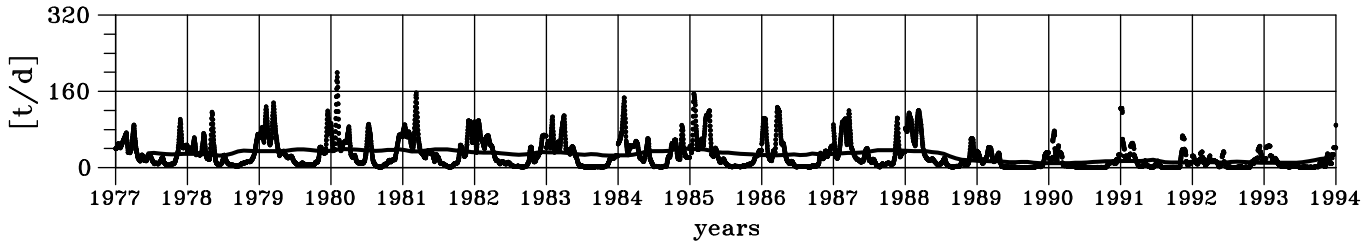
| year | t/y | year | t/y | year | t/y | year | t/y | year | t/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 11211 | 1984 | 12481 | 1991 | 5735 | 1998 | 1477 | 2005 | 1577 |
| 1978 | 9258 | 1985 | 11601 | 1992 | 3945 | 1999 | 4335 | 2006 | 1742 |
| 1979 | 13925 | 1986 | 10358 | 1993 | 3581 | 2000 | 2480 | 2007 | 876 |
| 1980 | 13142 | 1987 | 11590 | 1994 | 5783 | 2001 | 3693 | 2008 | 902 |
| 1981 | 14071 | 1988 | 11634 | | | 2002 | 1330 | 2009 | 1408 |
| 1982 | 10316 | 1989 | 3833 | | | 2003 | 2293 | | |
| 1983 | 9397 | 1990 | 3462 | | | 2004 | 1860 | | |

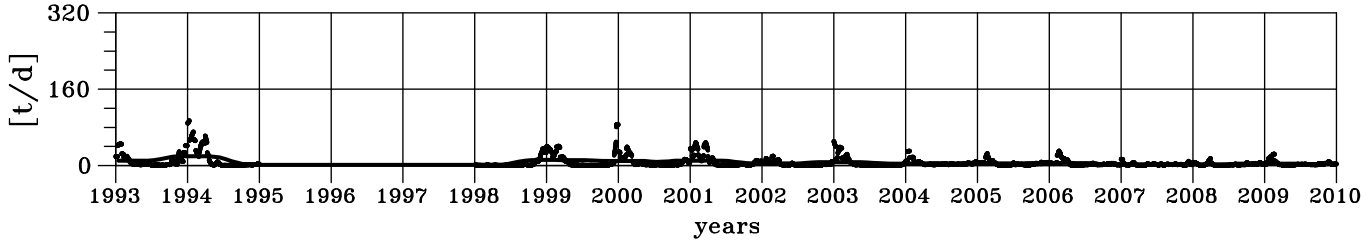
TIME SERIES
mean: 18.0 t/d
relative standard deviation: 1.31
minimum: 0.1 t/d September 13, 1999
maximum: 199.4 t/d February 1, 1980

LOW PASS
minimum: 0.9 t/d February 1998
maximum: 39.6 t/d November 1984

ANNUAL CYCLE
minimum: 2.4 t/d August, rel. stdev: 1.19
maximum: 40.6 t/d January, rel. stdev: 0.71



## Total Phosphorus load for River Schelde

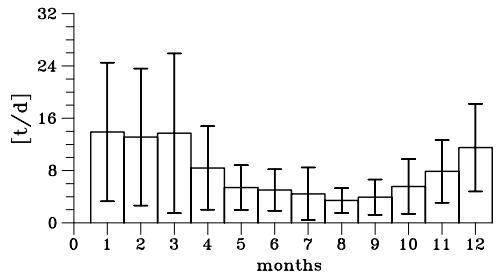
ANNUAL LOADS

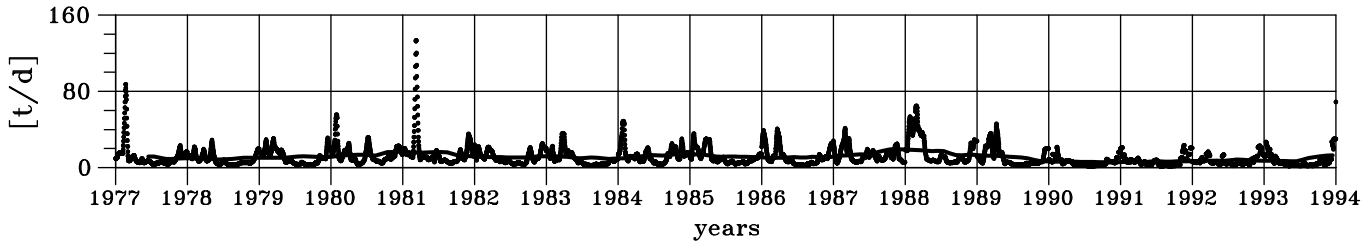
| year | t/y | year | t/y | year | t/y | year | t/y | year | t/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 4179 | 1984 | 4883 | 1991 | 2497 | 1998 | 2517 | 2005 | 771 |
| 1978 | 3082 | 1985 | 4070 | 1992 | 2670 | 1999 | 2212 | 2006 | 850 |
| 1979 | 4047 | 1986 | 4183 | 1993 | 2519 | 2000 | 2627 | 2007 | 1020 |
| 1980 | 4984 | 1987 | 4808 | 1994 | 4375 | 2001 | 1517 | 2008 | 1147 |
| 1981 | 5952 | 1988 | 6699 | 1995 | 2650 | 2002 | 1626 | 2009 | 723 |
| 1982 | 3911 | 1989 | 3953 | 1996 | 1570 | 2003 | 1715 | | |
| 1983 | 3387 | 1990 | 2094 | 1997 | 1471 | 2004 | 1706 | | |

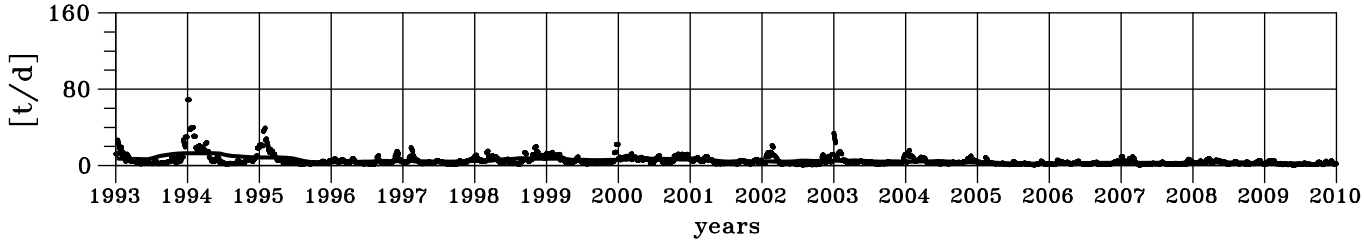
TIME SERIES
mean: 8.0 t/d
relative standard deviation: 1.09
minimum: 0.3 t/d May 25, 2009
maximum: 133.3 t/d March 11, 1981

LOW PASS
minimum: 1.9 t/d July 2009
maximum: 19.4 t/d November 1987

ANNUAL CYCLE
minimum: 3.4 t/d August, rel. stdev: 0.55
maximum: 13.9 t/d January, rel. stdev: 0.76



## Phosphate load for River Schelde

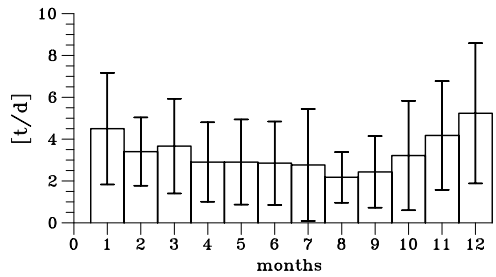
ANNUAL LOADS

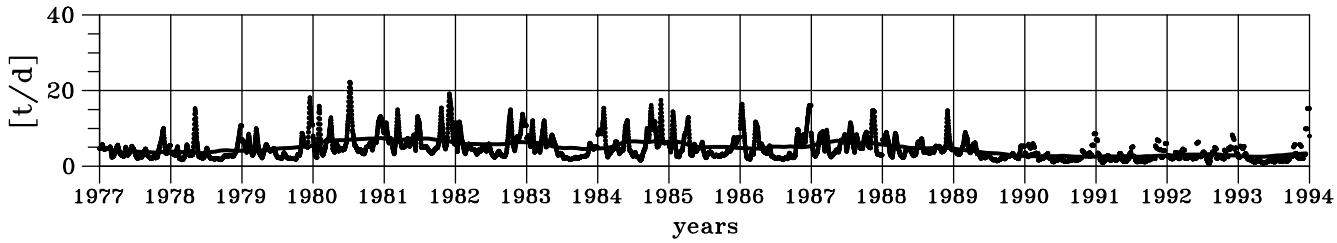
| year | t/y | year | t/y | year | t/y | year | t/y | year | t/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 1438 | 1984 | 2426 | 1991 | 949 | 1998 | 980 | 2005 | 460 |
| 1978 | 1320 | 1985 | 1808 | 1992 | 1132 | 1999 | 821 | 2006 | 553 |
| 1979 | 1733 | 1986 | 2003 | 1993 | 1033 | 2000 | 1152 | 2007 | 605 |
| 1980 | 2543 | 1987 | 2210 | 1994 | 1010 | 2001 | 835 | 2008 | 615 |
| 1981 | 2674 | 1988 | 1825 | 1995 | 925 | 2002 | 395 | 2009 | 472 |
| 1982 | 2131 | 1989 | 1249 | 1996 | 652 | 2003 | 613 | | |
| 1983 | 1696 | 1990 | 996 | 1997 | 670 | 2004 | 520 | | |

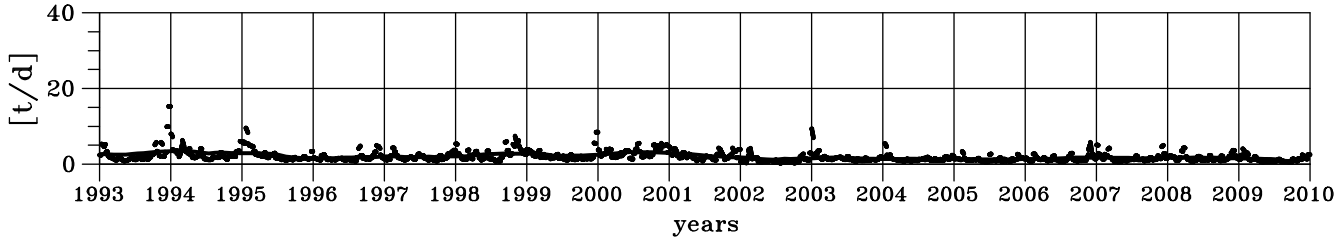
TIME SERIES
mean: 3.4 t/d
relative standard deviation: 0.82
minimum: 0.3 t/d January 31, 2002
maximum: 22.2 t/d July 7, 1980

LOW PASS
minimum: 1.1 t/d June 2002
maximum: 7.5 t/d December 1980

ANNUAL CYCLE
minimum: 2.2 t/d August, rel. stdev: 0.56
maximum: 5.2 t/d December, rel. stdev: 0.64



## Silicate load for River Schelde

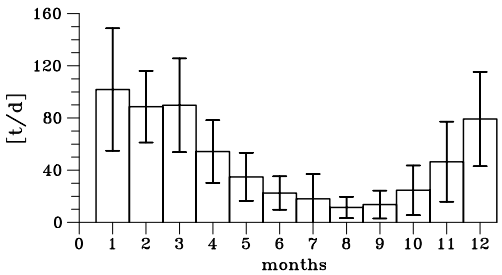
ANNUAL LOADS

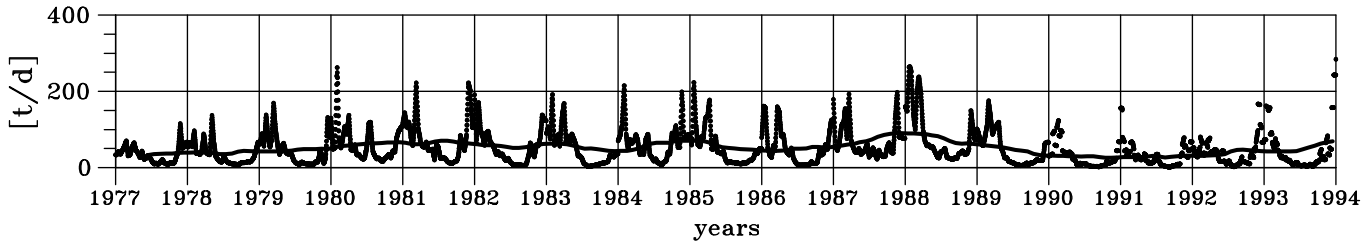
| year | kt/y | year | kt/y | year | kt/y | year | kt/y | year | kt/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 12.4 | 1984 | 23.6 | 1991 | 11.2 | | | 2005 | 11.8 |
| 1978 | 12.7 | 1985 | 18.9 | 1992 | 14.0 | 1999 | 23.2 | 2006 | 12.0 |
| 1979 | 16.7 | 1986 | 18.9 | 1993 | 16.4 | 2000 | 27.2 | 2007 | 17.8 |
| 1980 | 22.8 | 1987 | 24.7 | 1994 | 20.6 | 2001 | 19.5 | 2008 | 16.8 |
| 1981 | 25.9 | 1988 | 30.3 | | | 2002 | 12.5 | 2009 | 11.5 |
| 1982 | 19.2 | 1989 | 17.2 | | | 2003 | 17.0 | | |
| 1983 | 18.0 | 1990 | 10.3 | | | 2004 | 12.0 | | |

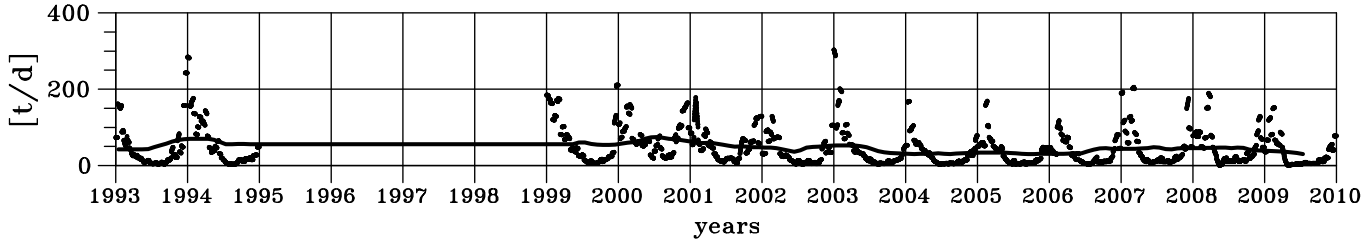
TIME SERIES
mean: 48.9 t/d
relative standard deviation: 0.88
minimum: 0.4 t/d May 15, 2008
maximum: 303.4 t/d January 1, 2003

LOW PASS
minimum: 25.8 t/d November 1990
maximum: 90.1 t/d November 1987

ANNUAL CYCLE
minimum: 11.5 t/d August, rel. stdev: 0.71
maximum: 101.8 t/d January, rel. stdev: 0.46



## Total Alkalinity load for River Schelde

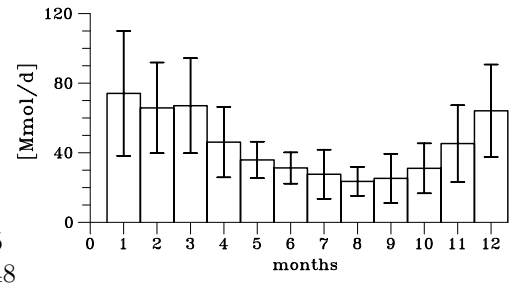
ANNUAL LOADS

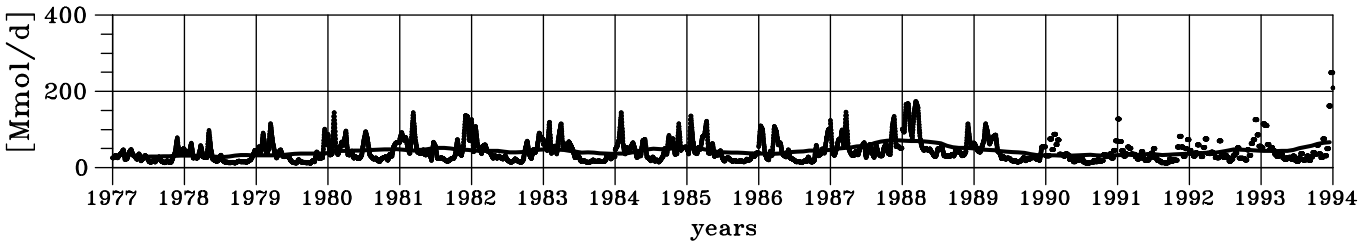
| year | Gmol/y | year | Gmol/y | year | Gmol/y | year | Gmol/y | year | Gmol/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 10.4 | 1984 | 17.9 | 1991 | 13.2 | 1998 | 19.8 | 2005 | 13.8 |
| 1978 | 10.0 | 1985 | 14.5 | 1992 | 15.6 | 1999 | 20.3 | 2006 | 14.3 |
| 1979 | 13.0 | 1986 | 15.6 | 1993 | 17.9 | 2000 | 23.2 | 2007 | 17.7 |
| 1980 | 16.4 | 1987 | 20.3 | 1994 | 21.3 | 2001 | 27.9 | 2008 | 17.5 |
| 1981 | 19.0 | 1988 | 24.3 | 1995 | 20.9 | 2002 | 10.5 | 2009 | 13.9 |
| 1982 | 14.8 | 1989 | 14.7 | 1996 | 11.4 | 2003 | 16.5 | | |
| 1983 | 14.2 | 1990 | 11.6 | 1997 | 12.2 | 2004 | 13.9 | | |

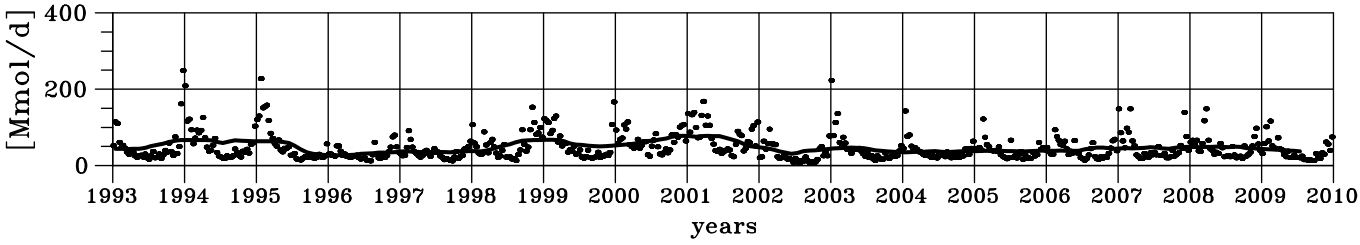
TIME SERIES
mean: 44.7 Mmol/d
relative standard deviation: 0.69
minimum: 5.6 Mmol/d July 21, 2002
maximum: 249.3 Mmold December 21, 1993

LOW PASS
minimum: 26.0 Mmol/d January 1996
maximum: 78.0 Mmol/d April 2001

ANNUAL CYCLE
minimum: 23.6 Mmol/d August, rel. stdev: 0.35
maximum: 74.1 Mmol/d January, rel. stdev: 0.48



## Dissolved Inorganic Carbon load for River Schelde

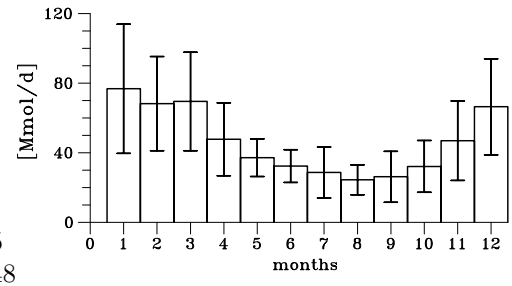
ANNUAL LOADS

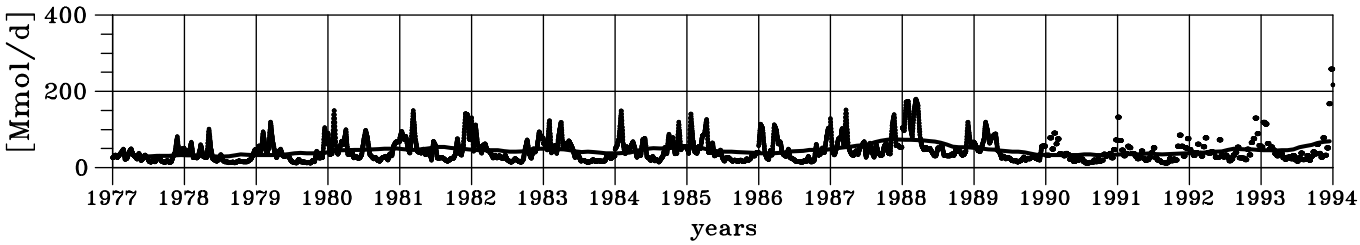
| year | Gmol/y | year | Gmol/y | year | Gmol/y | year | Gmol/y | year | Gmol/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 10.7 | 1984 | 18.6 | 1991 | 13.7 | 1998 | 20.5 | 2005 | 14.3 |
| 1978 | 10.4 | 1985 | 15.0 | 1992 | 16.1 | 1999 | 21.1 | 2006 | 14.9 |
| 1979 | 13.5 | 1986 | 16.2 | 1993 | 18.6 | 2000 | 24.0 | 2007 | 18.4 |
| 1980 | 17.0 | 1987 | 21.1 | 1994 | 22.0 | 2001 | 28.9 | 2008 | 18.2 |
| 1981 | 19.7 | 1988 | 25.2 | 1995 | 21.6 | 2002 | 10.9 | 2009 | 14.4 |
| 1982 | 15.4 | 1989 | 15.3 | 1996 | 11.8 | 2003 | 17.1 | | |
| 1983 | 14.7 | 1990 | 12.0 | 1997 | 12.6 | 2004 | 14.4 | | |

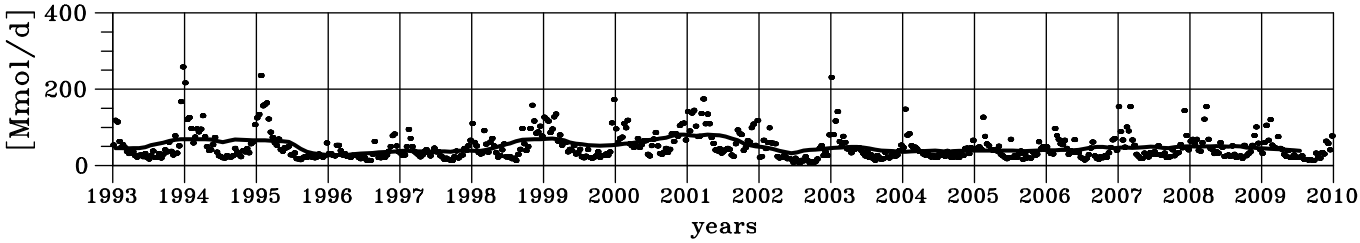
TIME SERIES
mean: 46.3 Mmol/d
relative standard deviation: 0.69
minimum: 5.8 Mmol/d July 21, 2002
maximum: 258.4 Mmold December 21, 1993

LOW PASS
minimum: 26.9 Mmol/d January 1996
maximum: 80.9 Mmol/d April 2001

ANNUAL CYCLE
minimum: 24.4 Mmol/d August, rel. stdev: 0.35
maximum: 76.8 Mmol/d January, rel. stdev: 0.48



## Dissolved Organic Carbon load for River Schelde

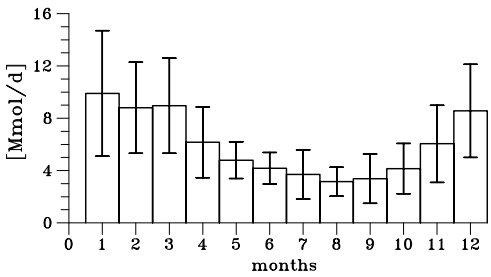
ANNUAL LOADS

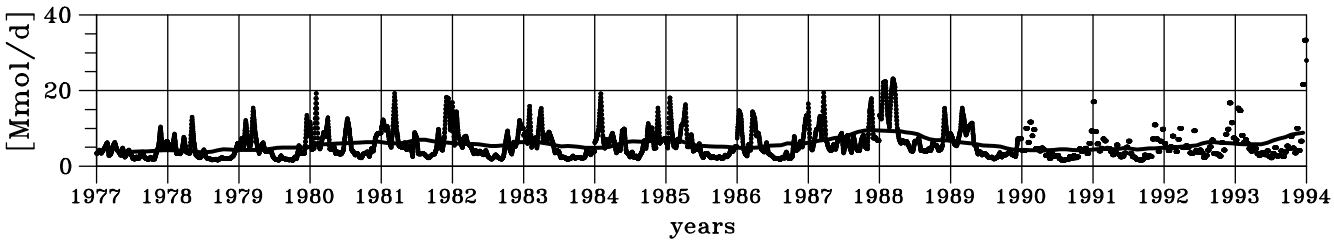
| year | Gmol/y | year | Gmol/y | year | Gmol/y | year | Gmol/y | year | Gmol/y |
|---|---|---|---|---|---|---|---|---|---|
| 1977 | 1.4 | 1984 | 2.4 | 1991 | 1.8 | 1998 | 2.6 | 2005 | 1.8 |
| 1978 | 1.3 | 1985 | 1.9 | 1992 | 2.1 | 1999 | 2.7 | 2006 | 1.9 |
| 1979 | 1.7 | 1986 | 2.1 | 1993 | 2.4 | 2000 | 3.1 | 2007 | 2.4 |
| 1980 | 2.2 | 1987 | 2.7 | 1994 | 2.8 | 2001 | 3.7 | 2008 | 2.3 |
| 1981 | 2.5 | 1988 | 3.3 | 1995 | 2.8 | 2002 | 1.4 | 2009 | 1.9 |
| 1982 | 2.0 | 1989 | 2.0 | 1996 | 1.5 | 2003 | 2.2 | | |
| 1983 | 1.9 | 1990 | 1.5 | 1997 | 1.6 | 2004 | 1.9 | | |

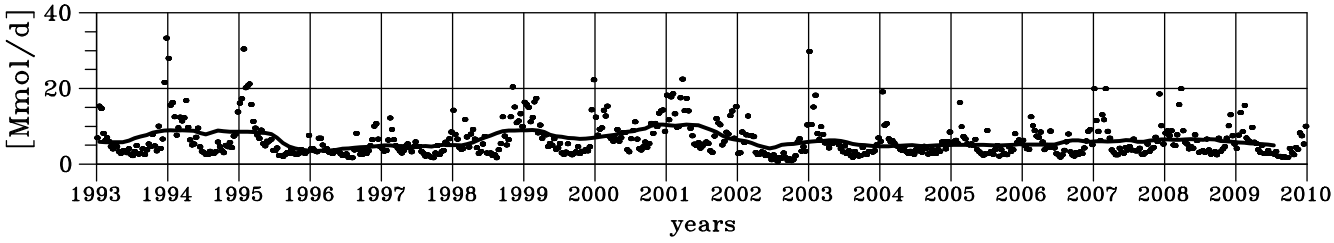
TIME SERIES
mean: 6.0 Mmol/d
relative standard deviation: 0.69
minimum: 0.8 Mmol/d July 21, 2002
maximum: 33.3 Mmold December 21, 1993

LOW PASS
minimum: 3.5 Mmol/d January 1996
maximum: 10.4 Mmol/d April 2001

ANNUAL CYCLE
minimum: 3.2 Mmol/d August, rel. stdev: 0.35
maximum: 9.9 Mmol/d January, rel. stdev: 0.48



# 6 Acknowledgements

We have to thank many people for their help in making river data available for this report. We have mentioned the different contributions by the institutes in the text, but in addition we would like thank M. Bergemann from ARGE, W. Wiechmann from the Bundesanstalt für Gewässerkunde in Koblenz, D. Steffen of the NLWKN in Hildesheim for their persistent help over many years in making new datasets available for us and to clear the way of how to make the load estimates work.

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