FURTHER DEVELOPMENT AND IMPLEMENTATION OF AN EU-LEVEL FOREST MONITORING SYSTEM

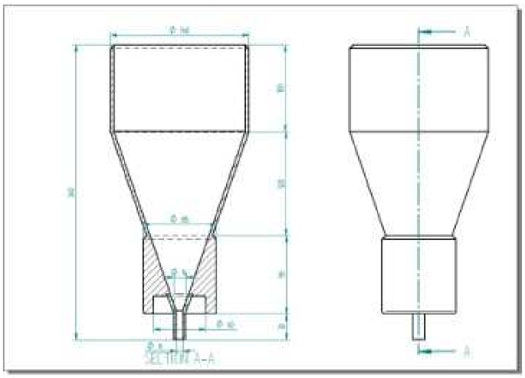
– FUTMON –

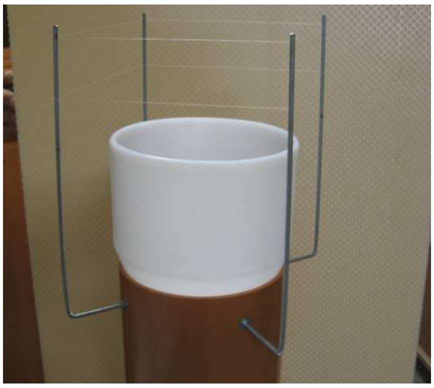
Technical Report Life+ QA-Depo10

Report on the experimental installation of standardized throughfall collectors

C1-Dep-22(SI)

Daniel Žlindra, Klemen Eler, Karin Hansen, Nicholas Clarke





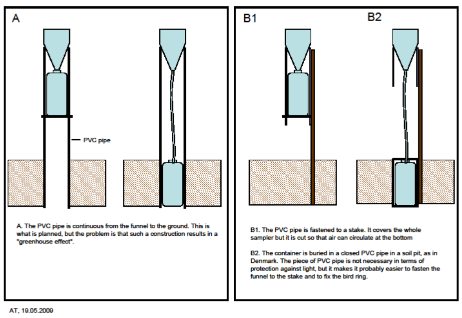


Figure by: A. Thimonier

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Žlindra D, Eler K, Hansen K, Clarke N, 2011: Report on the experimental installation of standardized throughfall collectors, 122 pp. ISBN: 978-961-6425-56-8

Printed in 50 copies

Work was done within the Life+ project FutMon (Life07 ENV/D/000218)

Issued by:
Slovenian Forestry Institute, *Silva Slovenica*, Večna pot 2, 1000 Ljubljana

www.gozdis.si

Ljubljana, 2011

Republic of Slovenia

Ministry of Agriculture, Forestry and Food,

Republic of Slovenia

Ministry of the Environment and Spatial Planning,

FUTMON

Life+ Life07 ENV/D/000218 (FutMon)

CIP - Kataložni zapis o publikaciji
Narodna in univerzitetna knjižnica, Ljubljana

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FURTHER development and implementation of an EU-level forest monitoring system : FutMon : technical report Life+ QA-Depo10 : report on the experimental installation of standardized throughfall collectors : C1-Dep-22(SI) / Daniel Žlindra ... [et al.]. - Ljubljana : Slovenian Forestry Institute, 2011

ISBN 978-961-6425-56-8
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1. Introduction

The Life+ project FutMon (Further development and implementation of an EU-level forest monitoring system, LIFE07 ENV/D/000218; January 2009 – June 2011) started in January 2009. One action in FutMon was C1-Dep-22(SI): Quality, expertise and evaluations within deposition surveys. It aimed at the refinement, harmonization and development of deposition monitoring methods and included the coordination of a comparison of all types of deposition collectors.

Since the beginning of forest monitoring within the ICP Forests program the methods and approaches have differed from country to country, especially for Level II activities. Therefore, one of the main objectives of the FutMon project was harmonizing the monitoring methods. Harmonizing principles, approaches, laboratory methods, field procedures, and thus the Manual were made with the purpose of establishing a monitoring network where all retrieved data are comparable and easily processed.

Methods to measure deposition to forest are rarely compared. Ziegler et al. (2009) compared stationary and mobile collectors in tropical rain forest and discovered good agreement at precipitation amounts higher than 700 mm. The comparison of twenty throughfall sampling systems used by different participating countries of the ICP Forests network, Bleeker et al. (2003), found fairly good agreement between systems with large enough collector size and total coverage area but weaker agreement for smaller collectors where spatial variation gave a more pronounced difference from the best estimate (average of all systems). The authors stressed the significantly higher importance of field methods (collector type, placement and storage, size, total cover area) compared to laboratory methods in accurately assessing the throughfall fluxes.

The Expert Panel on Deposition of ICP Forests (EPD) made a prototype of a collector (harmonized collector), which fulfils all the requirements of the WMO (2008) for precipitation collectors. It can be applied in all regions of Europe, taking into account all limiting circumstances (e.g. type of precipitation – hard, heavy rain, amount of precipitation in certain periods – a storage container of 5 litres volume) because of its universal design. The collectors were exposed for one year, excluding snow periods. The number of the collectors is recommended in the ICP Forests Manual Chapter XIV (Clarke et al., 2010), generally depending on type and homogeneity of the forest stand (conifers or broadleaf species, one or two main tree species), age, canopy closure etc. Because of high variability of the designs of the plots and the national collectors among the participating countries, other crucial parameters weren't changed on the country (plot) level; i.e. generally only the collectors were different. It was suggested that the spatial design should be as far as possible similar to the spatial design of the national collectors and the sampling frequency of the harmonized collectors should be the same as for the national collectors, as well as the procedures for cleaning the collectors, bulking the samples and analysing them.

2. Timetable of actions and procedures

The kick-off meeting took place in Hamburg in January 2009. The EPD had a discussion and planned the deposition-related activities in FutMon. The schedule of important activities was made (Table 1). It was decided that (**Annex 1**: Minutes of the meeting):

1. The comparison will be performed using both bulk and throughfall rain collectors, but not snow collectors.

2. The number of collectors will be 30 for throughfall and 3 for bulk precipitation.

3. The plot size should be according to the manual, but plot structure could vary between countries. A combined systematic/random distribution of standard collectors should be used (see Fig. 4 in the revised deposition sub-manual). It is recommended to set up the harmonised collectors in the buffer zone of the plot.

4. The sampling frequency will be according to the national system.

5. Pooling of samples will unfortunately be necessary because of the costs of analysing individual samples. This will give one throughfall sample and one bulk sample per sampling occasion for both the national and the harmonised collectors. Pooling (if this should be necessary) can be carried out in either the field or the lab, using either weights or volumes. More detailed instructions for pooling will be sent out.

6. The harmonised collector should be constructed according to what is written in the Manual ("The sampling equipment should consist of a funnel and a receiving vessel. The material used for the collector should be high density polyethylene. The sampling area should be horizontal and the upper part of the collector vertical. The surface of the collector must be smooth. The height of the sampling surface should be 1 m above ground level. An inert sieve with a mesh size of 1 mm should be placed loosely at the top of the neck of the funnel. Sample containers should be kept cool and in the dark"). It should have a bird ring. The diameter will be 16 cm, not 20 cm. The storage container will be 4 l, and placed in the ground if this is possible. Fencing will be according to the national system.

7. Funnels and storage containers will be cleaned according to the national system.

8. Equipment should be ordered by 1 March and installed by 31 May.

In the beginning of March the "Invitation" (**Annex 2**) was circulated to all the associated beneficiaries of the FutMon project. The "Guidelines" (**Annex 3**) followed later in March. Some changes were made regarding the Minutes mainly because of practical reasons and physical limitations. According to point 3 (Annex 1) the installation of the collectors should preferably be in the buffer zone and they should be distributed systematically/randomly. Different countries use different installation of the deposition collectors in the plot (buffer zone / inner plot). The plot is dedicated to several research topics and it is sometimes hard to find place for all of the equipment and undisturbed places for vegetation observations and similar. We decided that we do not like to influence the plots more than necessary, so the arrangement of the standardized collectors should follow the arrangement of the national ones (judgment design, systematic-random, subplots).

Another change in the field protocol was related to the placement of the collectors. The comparison of the two types of collectors will be difficult if both collectors don't cover the same reference area. That suggestion was included in the "Guidelines" too (**Annex 3**).

Table 1: Proposed timetable of the C1-Dep-22(SI) activities.

Activity	**I/ 2009**	**II/ 2009**	**III/ 2009**	**IV/ 2009**	**I/ 2010**	**II/ 2010**	**III/ 2010**	**IV/ 2010**
Selection of the collector	√							
Installation	√							
Sampling		√	√	√	√			
Analyses of samples		√	√	√	√	√		
Reporting of results to Ass. Ben.							√	
Evaluation and reporting to Coor. Ben.								√

In May 2009 the collectors were ordered and delivered to the associated beneficiaries. Some minor delays were detected. The first associated beneficiary started the sampling on 1.6.2009 and the last on 24.9.2009. Since a period of one year sampling was necessary to provide a thorough intercomparison (where the snow period was excluded), the sampling ended in the period from 1.6.2010 to 31.10.2010, depending on the associated beneficiary.

The "Call for data" (**Annex 4**) was circulated in July 2010 with detailed instructions about what, how and when to report. For the purpose of checking data, the FutMon data base was opened for uploading and validating the files. Separate files with data (quantities and chemical analysis results) in MS Excel format and a file with the information about sampling design, sampling periods, storage and sample preparation (Data Accompanying Report – DAR-Q, **Annex 5**) in MS Word format were sent to the responsible associated beneficiary. The deadlines for the quantities report and chemical analysis report were 31.8.2010 and 31.10.2010 respectively.

3. Materials and Methods

3.1. Collector set-up

The harmonized collector (**Annexes 6, 7**) was designed according to WMO guidelines by the members of the EPD. Because of lack of time some details were not agreed upon. Therefore the leading associated beneficiary had to take further decisions. The collector is made of white polyethylene and consists of two parts: the funnel and the collecting bottle. There is a coil in between with the purpose of connecting them more easily. The side of the funnel is steep preventing raindrops from splashing out of the funnel. The surface is smooth. The rim of the funnel is vertical from the inside and steep from the outside and the edge is sharp. The diameter of the funnel is 159 mm. From that the capturing area is 199 cm^2 and the total capturing area of 30 collectors 5957 cm^2 .

The bottle is made of the same material and has a capacity of 5 litres. The capacity was calculated according to the collecting area of the funnel, maximum expected precipitation and time between two sampling events of the associated beneficiary with limiting cases.

The collector set-up in the plot was a topic for discussion in order to achieve the lowest temperatures in the bottle so as to minimise microbial transformations, effective protection against sunlight, have the lowest possible costs or even to have the opportunity to place the collectors in the plot in the first place because of the physical limitations such as stony soils and similar problems. Four set-ups were proposed (Fig. 1).

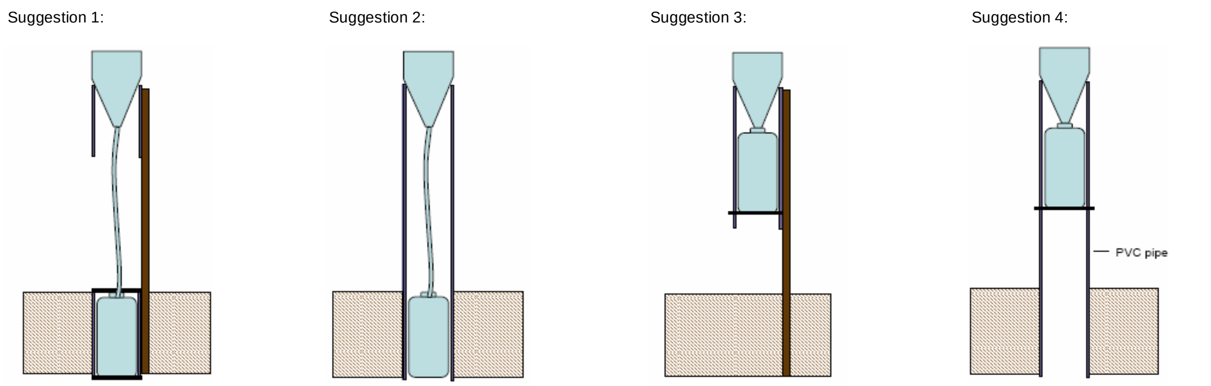

Fig. 1: Proposed set-ups of the collector in the field. (Figure by A. Thimonier)

The associated beneficiaries were free to choose any set-up that suited them, according to the special conditions on their plot. The majority of associated beneficiaries chose suggestion 4 (10 associated beneficiaries), suggestions 2 and 3 were represented equally (2 associated beneficiaries each), and suggestion 1 was not used.

A nylon mesh with the pore size of 1 mm was used for preventing litterfall from falling into the sample. Where this was not an issue (in one case) the meshes were omitted.

Another factor which influences the chemical composition of the sample is when birds sit on the rim of the funnel and drop their excrements. There are ways to prevent birds from sitting on the rim by the use of “bird rings”. The type of the suggested model is used in the UK monitoring system, but supplemented with an extra disturbance line at half the height of the primary ring in order to make an universal bird ring, useful against both large and small birds. The nylon line is thin and relatively far from the funnel. No influence on the amount of collected precipitation is presumed.

The plots chosen (Table 2) were mostly conifers (*Pinus sp.* and *Picea sp.*, 10 plots). Six plots consisted of broadleaves (*Quercus sp.* and *Fagus sylvatica*). Even though the types of main tree species were different, the number of harmonized collectors was 30 on all plots.

An important question was whether to install the collectors in the inner plot or in the buffer zone? It later turned out that there is no unique answer to that. Finally, it was proposed that the set-up of harmonized collectors follows the set-up of the national collector. As a consequence the set-up of harmonized collectors in the plot differed between countries since the set-up of the national collectors differs from country to country. Mainly the collectors were assessed in the plot (9), followed by those who assessed in the buffer zone (4) and some associated beneficiaries decided to combine the number of harmonized collectors in the plot and in the buffer zone (3).

3.2. Chemical analysis

Each associate beneficiary was responsible for chemical analyses of the samples collected during the experiment. Only analyses for mandatory parameters according to the ICP Forests Manual (Clarke et al., 2010) were performed. The samples were usually delivered to the laboratory in less than one day (three fourths of the associated beneficiaries), but it also took up to 60 days. Two thirds of the associated beneficiaries delivered the samples to the laboratory by car and the rest of them sent them by mail. The samples were transported in laboratory bottles or in the collection container itself. Storage temperature was about 4 °C, but three associated beneficiaries froze their samples when they waited for the analysis. The majority of the associated beneficiaries stored their samples in polyethylene bottles. Other options were HDPE, polycarbonate, PVC or PET bottles. The samples were prepared/conserved by filtering by all the associated beneficiaries. The analyses were done as soon as possible.

Table 2: Participating countries (associated beneficiaries) along with the basic information about the investigation plot and sampling.

Country name*	Associated Beneficiary code**	Plot number	Dominant tree species	Stand age (in years)	Type of national throughfall collector	Type of national bulk collector	Sampling frequency (in days)	Collector placement	No. of national throughfall collectors	No. of harmonized throughfall collectors	Dependent / independent set-up of throughfall collectors	No. of national bulk collectors	No. of harmonized bulk collectors
Austria	02	15	*Picea abies*	70	funnel	funnel	14	in line	15	30	Indep.	3	3
Belgium / Flanders	03	15	*Pinus sylvestris*	80	funnel	funnel	14	crossed lines	10	30	Dep.	4	3
Czech Republic	07	561	*Picea abies*	108	gutter	funnel	10	grid + random	3	30	Indep.	2	3
Estonia	09	7	*Pinus sylvestris*	82	funnel	funnel	14	grid	20	30	Dep.	5	3
Finland	10	17	*Picea abies*	75	funnel	funnel	14 – 30	grid	50	30	Dep.	3	3
France	11	30	*Quercus petrea/robur*	128	gutter	funnel	14	grid	3	30	Indep.	2	3
Germany	30	1501	*Pinus sylvestris*	92	funnel	funnel	14	grid	15	30	Indep.	3	3
Greece	12	1	*Quercus ilex*	40 – 60	funnel	funnel	7	random	30	30	Dep.	3	3
Hungary	13	1	*Fagus sylvatica*	99	funnel	funnel	7	grid + random	12	30	Indep.	4	3
Ireland	14	16	*Picea sitchensis*	34	funnel	funnel	7	random	30	30	Dep.	4	3
Italy	40	05	*Quercus petraea, C. Cerris*	60	funnel	funnel	7	grid	16	30	Dep.	3	3
Poland	18	405	*Pinus sylvestris*	74	funnel	funnel	28 - 35	in line	15	30	Indep.	3	3
Slovakia	21	208	*Fagus sylvatica*	52	funnel	funnel	14	random	10	30	Indep.	3	3
Slovenia	22	4	*Pinus sylvestris*	107	gutter	funnel	14	in line	10	30	Dep.	3	3
Spain	23	37	*Pinus pinaster*	41 – 60	funnel	funnel	28	random	6	30	Indep.	4	3
United Kingdom	26	512	*Quercus robour*	75	funnel	funnel	28	crossed lines, grid	10	10	Indep.	2	3

* - some associated beneficiaries (8 – Denmark and 20 – Romania) performed another throughfall comparison to complement this experiment which is not presented in this report.

** - only the associated beneficiary code is presented in further figures and tables.

3.3. Statistical approaches in assessing the agreement between methods

When a new measurement method or device is developed it is important to test its agreement with some other standardized or established method. The agreement is considered adequate when we might replace the new method with the older one taking into account the required accuracy of the measurement.

To test for agreement, preferentially the same samples are measured using both methods. Within measurement comparison approaches, agreement is evaluated by testing for the significant systematic difference. This difference or bias can be fixed when it is not related to the absolute value of the variable measured, or proportional when the difference is increasing or decreasing with the increase of the quantity. What is sought for in method comparison studies is actually not the agreement but the bias (Ludbrook, 2002; Westgard, 1998) which results from the statistical foundation itself. At a certain confidence level only the rejection of the zero hypothesis stating the agreement between methods is possible but not its confirmation.

Different statistical techniques are used to test for bias significance: regression methods, Altman-Bland plot, ANOVA approaches, kappa statistics, structural equation modelling, etc. The choice is dependent on the type of variables being studied (continuous vs. categorical) (Ludbrook, 2002; Bland and Altman, 2007), the presence of a gold-standard method to be compared to (Astrua et al., 2007), the number of replicate measurements per sample and study design.

In cases where errors, not controlled by the researcher, are present in both methods, Model II regression approaches (Rolf and Sokal, 1995; Legendre and Legendre, 1998) such as Deming regression (also known as major axis regression or least product regression) should be used. Deming regression minimizes the perpendicular distances between points and regression line (Linnet, 1993) and allows values of both methods to be attended by random error. The method assumes constant standard deviations across the range of values. When deviations change considerably, weighted variants of the methods are preferable (Linnet, 1993). Whatever regression approach is chosen, the fixed and proportional bias of the new method is determined using intercept and slope estimates, respectively, together with the confidence intervals for each parameter. Significant fixed bias is ascertained when intercept confidence intervals do not contain 0 and proportional bias is significant when slope confidence intervals do not contain 1.

A simple but efficient approach was proposed by Altman and Bland (1983, 1986). They stated that it is the differences between methods which are most useful in searching for bias. By plotting the differences of the methods against their means and computing mean difference and 95% confidence intervals for the difference (a.k.a. limits of agreement) one can easily determine how good the agreement between the methods is and if the confidence interval is within the reasonable limits for the accuracy required from specific measurement. Limits of agreement are calculated as:

$$\overline{D} \pm z_{2\alpha} \cdot SD,$$

where $\overline{D}$ is the mean difference between methods, $z_{2\alpha}$ is the standardized normal deviate of two sided P=0.05 (1.96) and SD is the standard deviation of differences.

In the case of smaller sample size (n), a more conservative approach using the Student t distribution is preferable (Ludbrook), which is calculated as:

$$\overline{D} \pm t_{n-1,2\alpha} \cdot SD \cdot \sqrt{(1+1/n)},$$

where $t_{n-1,2\alpha}$ is the value of the t distribution corresponding to two sided P=0.05 for n-1 degrees of freedom and $\sqrt{(1+1/n)}$ is the correction for small sample size.

Besides from determination of fixed bias (mean difference tested using a paired t-test) the Altman-Bland method can also estimate proportional bias if the differences are regressed against the means. If no proportional bias is expected, the slope of that regression line will not significantly differ from 0, which is determined by looking at the slope confidence intervals.

Both Deming regression and the Altman-Bland approach are used on the data in this report.

4. Results and Discussion

4.1. Spatial representativity

We assumed that 30 harmonized collectors were spatially representative across a wide range of forest ecosystems and canopy closures. Therefore, the spatial representativity of national collectors was evaluated in terms of sample size (number of collectors) and total cover area of the collectors (Table 3). For throughfall both sample size and collecting area of the national collectors of most of the associated beneficiaries were below the values of the harmonized system. For national bulk precipitation collectors, only two beneficiaries were below the values of harmonized system for sample size and one for collecting area.

Table 3: Number and collecting area of national collectors and their spatial representativity compared to the harmonized collectors. Blue shading – values for the national collectors above or equal to the values for the harmonized collectors, yellow shading - values for the national collectors below the values for the harmonized collectors.

	Throughfall		Bulk	
Associated beneficiary code	Number of collectors	Collecting area of collectors (cm^2)	Number of collectors	Collecting area of collectors (cm^2)
02	15	3817	3	763.4
03	10	1539	4	615.8
07	3	12000	2	852
09	20	3000	5	750
10	20	2513	3	942.5
11	3	8500	2	600
12	30	No data submitted	3	No data submitted
13	12	3770	4	1257
14	30	No data submitted	4	No data submitted
18	15	1612	3	530.1
21	10	1990	3	597
22	10	1850	3	1246.4
23	6	679.6	4	452.4
26	10	1767	2	353.4
30	15	4713	3	942.6
40	16	4778	3	896

4.2. Bulk precipitation and throughfall quantities

Different construction details of the collectors and the spatial representativity of the area covered, such as collector slope, rim size and shape, and total area covered might affect the precision of throughfall and bulk precipitation quantity measurements. A comparison was made between the amount of precipitation collected in the national collectors and precipitation collected with harmonized collectors. The associated beneficiaries already had to report calculated amount of precipitation per unit of area in millimetres (=litres per square meter).

Different graphical representations for each associated beneficiary are shown in **Annex 8** of this report. An example is given in Fig. 2.

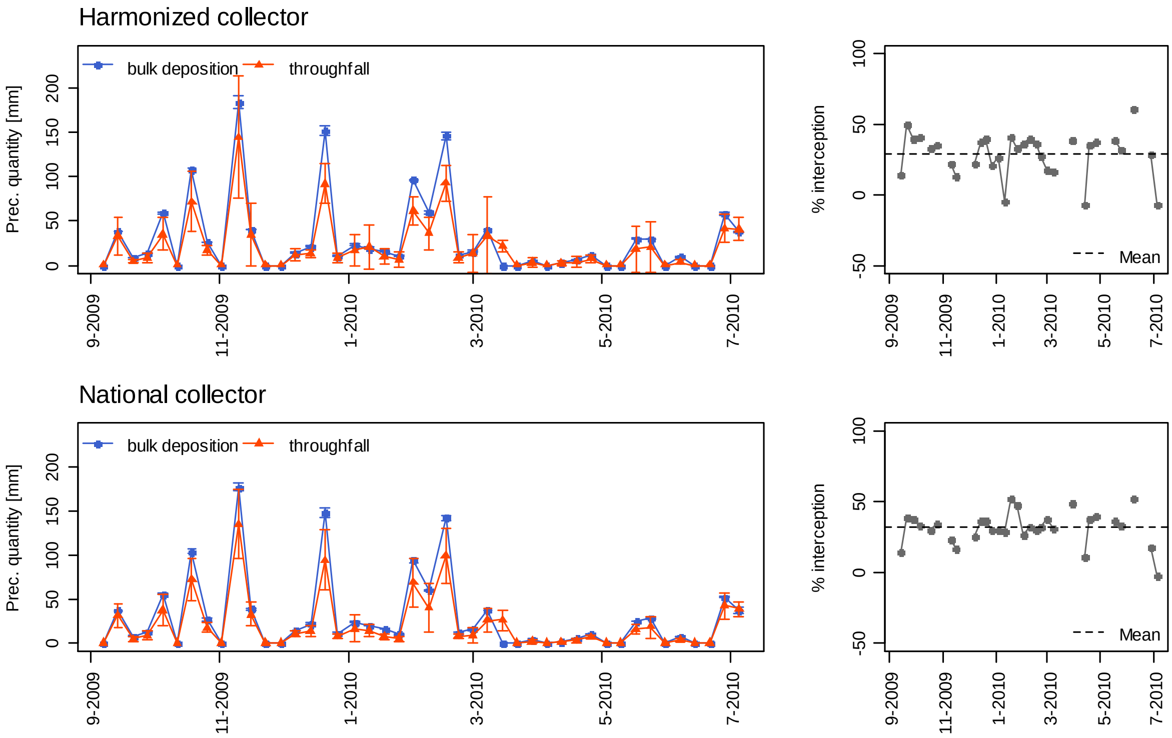

Fig. 2: Example of precipitation quantity (in mm) and interception (in %) of both types of collectors for both bulk and throughfall precipitation. Means ± SD are shown. Contrary to the established representation of precipitation we used interaction-plot-like graphs to better visualize the differences in courses. In most cases unaggregated precipitation was reported (for each collector separately) which gave the opportunity to estimate variability; in this respect mean precipitation ± standard deviation are shown.

Next, the agreement between the national and harmonized collectors is presented in Fig. 3. The first set of three charts presents the situation for the sampling in the open-field (bulk) and the three figures below the results for throughfall. In the left chart, the absolute values (mean precipitation per sampling term) in the time series is presented. Here, the difference in measured quantities with both types and in both conditions (open-field, throughfall) are more clearly visualized.

In the middle chart the quantities in the harmonized collectors versus the quantities in the national collectors are presented. The solid line corresponds to the Deming regression line and the dashed line is the 1:1 line. Influential data pairs (large leverage) are shown by hollow symbols and are not included in the calculation.

On the right side the Altman-Bland plot follows. The dots present the difference between the quantities measured with harmonized and with national collectors plotted against the mean of both values. The position in the ordinate direction corresponds to the mean of each pair of the measurement. The dashed line represents the average of the differences. The dotted lines represent the two boundaries of two standard deviations in the positive and negative direction. The solid line is the regression line of differences on means showing the proportional bias of the measurements.

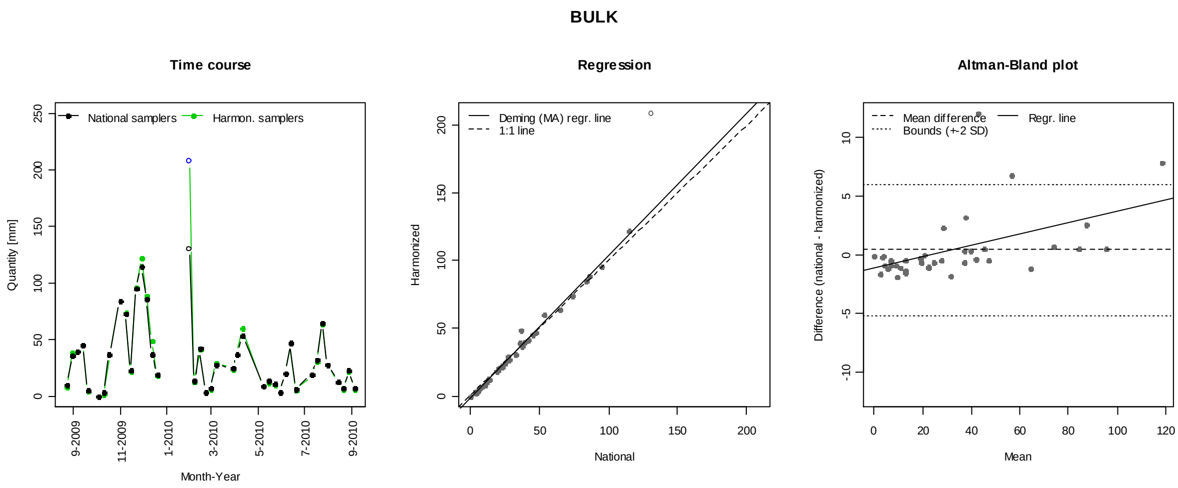

Fig. 3: Agreement between the quantity, captured with two kinds of collectors, presented in three ways: absolute time course, regression plot and Altman-Bland plot.

The general pattern of precipitation of the harmonized/national collectors agreed for almost all associated beneficiaries. Only in a few cases did exceptions occur. Outliers were detected and removed. In one case the precipitation was extremely high compared to quantities on other sampling occasions and in two other cases the quantities were in the range of other sampled quantities. There was no remark for these events therefore we can suspect that heterogeneous atmospheric conditions were present in those periods. The national collectors of associated beneficiaries 14 and 40 have a different geometry than the harmonized collector. In particular, the vertical part of the funnel in the national collectors is short. In combination with heavy rain and strong wind, when the kinetic energy of the raindrops is high, they splash intensively, also outside the funnel. The result can be less precipitation captured in such collectors.

5 out of 16 associated beneficiaries reported a difference between the throughfall quantities captured by national or harmonized collectors higher than 10% (up to 32%) in a positive or negative direction (Fig. 4). There are several possible causes for this: dimensions and geometry of the funnel / gutter, the plane of the capture area and the correct measurement of the capture area. In the case of associated beneficiary no. 11 the spatial arrangement of the collectors in the stand was significantly different for the national collectors (placement under the canopy) compared to the harmonized collectors (placement under open spaces) (Thimonier, 1998).

For bulk precipitation the deviations were significantly lower. The disagreement between both types of collector was higher than 10% in two cases only, although not higher than 15%, which seems to be sufficient precision.

One possible cause for the deviations is extreme meteorological conditions, such as heavy rain in combination with hard wind etc. Also, it is possible that associated beneficiaries reported values for periods with snow without knowing because the snow melted prior to the sampling event. In these cases, the source of difference can be when snow amounts in the national collectors differed from in the harmonized collectors.

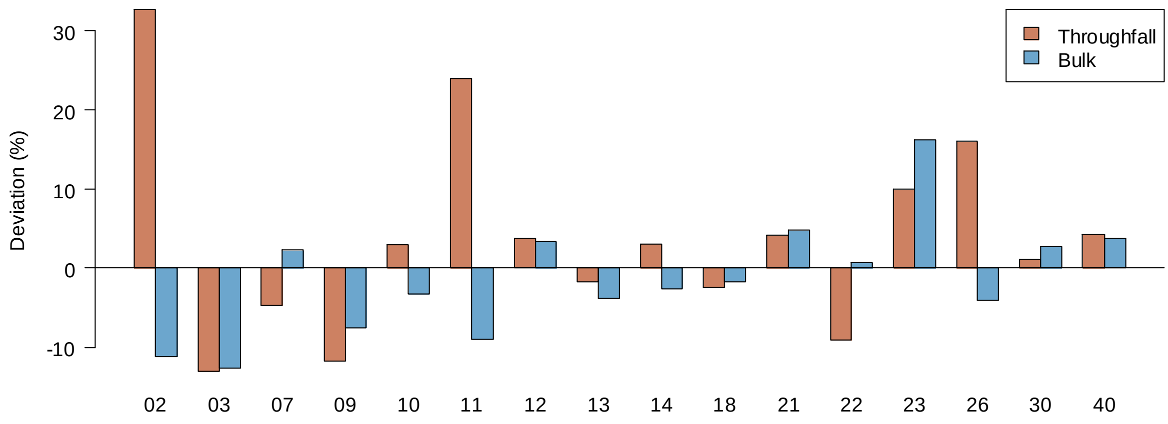

Fig. 4: Median deviations of quantities between national and harmonized collectors for throughfall and bulk precipitation. Positive values – higher water quantities measured by harmonized collectors; negative values – higher water quantities measured by national collectors.

Further, we compared the measured quantities for different types of forest or main tree species (Fig. 5). The deviation was lower in the plots with broadleaf trees (mainly *Quercus sp.,* one plot with *Fagus sylvatica*) than in the plots with conifers (*Pinus sp.*, 6 plots, *Picea sp.,* 4 plots). The median deviations for conifers and for broadleaves were not significantly different from zero.

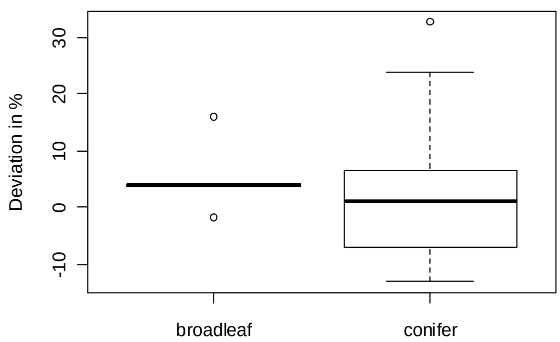

Fig. 5: Comparison of median deviations of quantities between broadleaved and coniferous forests.

The general pattern of the precipitation quantities is as expected. Results (Figs. 6 and 7) are valid for the time period where all data are complete. This is why the number of days in the figure in some cases is not the same as reported.

Differences between the national and harmonized collectors for throughfall can be observed for associated beneficiaries 2, 3, 9, 11, 14, 22, 26 and 40. They have more than 50 mm absolute difference in favour of harmonized collectors, except for 3 and 22 where the situation is the opposite. In the case of associated beneficiary 22, the difficulties of measuring the proper capture area of the national collector (gutter, made of tube – lack of rim) can be the main cause of the deviation.

For bulk precipitation, only associated beneficiaries 14, 21, 23, 30 and 40 have more than 50 mm absolute difference with more precipitation in the harmonized collectors, while 3 and 26 have more than 50 mm absolute difference with more precipitation in the national collectors.

In most cases, the overall interception was positive except for the national collectors of associated beneficiary 22 and the harmonized collectors of associated beneficiary 26.

More detailed results for each associated beneficiary can be found in **Annex 8**.

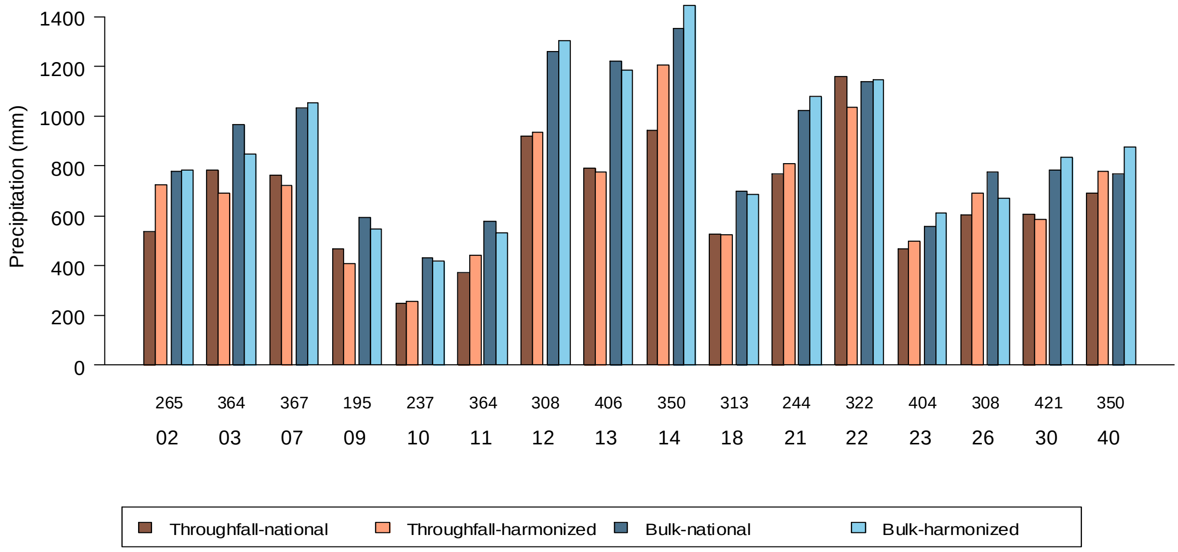

Fig. 6: Total precipitation and throughfall quantities (mm) for associated beneficiaries. Values above associated beneficiary numbers show the number of sampling days, for which all data are complete.

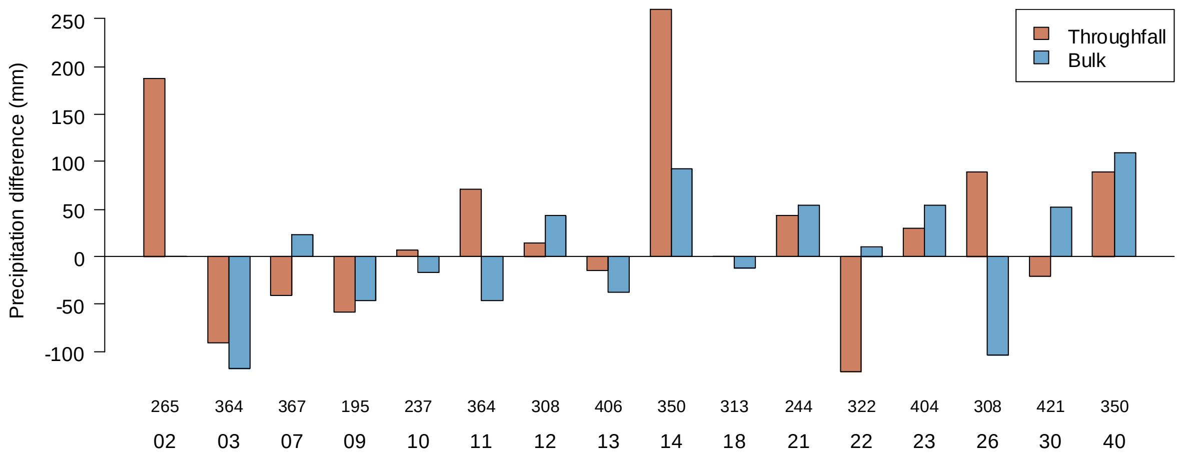

Fig. 7: Difference in quantities (mm) between harmonized and national collectors for throughfall and bulk precipitation. Values above associated beneficiary numbers show the number of sampling days, for which all data are complete. Positive values – higher precipitation measured by harmonized collectors; negative values – higher precipitation measured by national collectors.

Using the Deming regression approach a statistically significant agreement was found in quantities between national and harmonized collectors for both bulk precipitation and throughfall (Fig. 8), indicating large data consistency in precipitation quantities across beneficiaries and the different sampling designs.

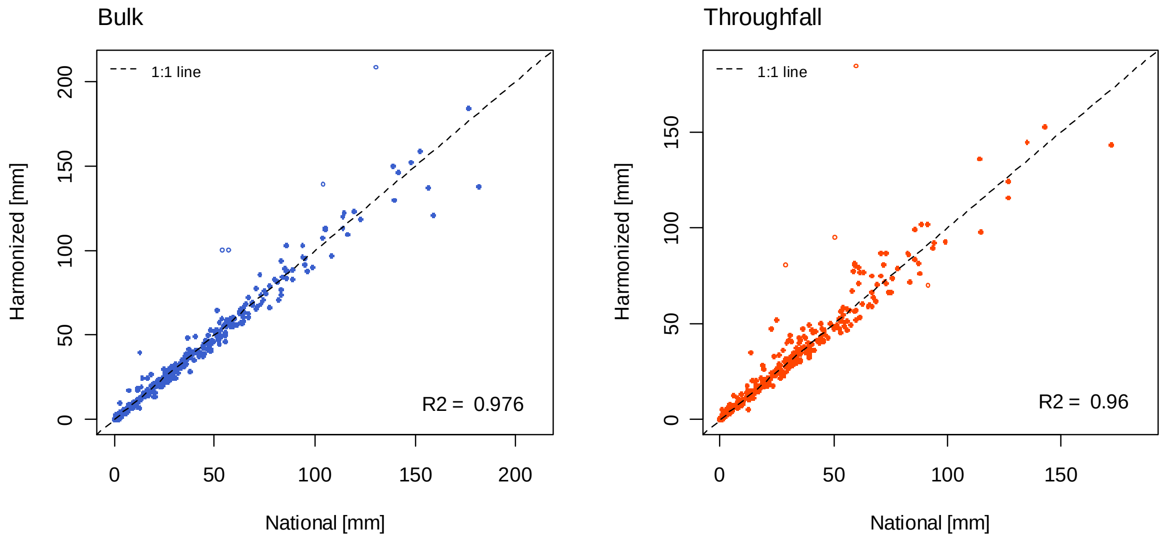

Fig. 8: Combined plots of bulk precipitation and throughfall (both in mm) for all associated beneficiaries for both national and harmonized collectors.

4.3. Chemical analysis

A two step approach was used. First the concentrations were taken into account and secondly deposition values, which depend on both concentrations and quantities so that their deviation reflects the deviation of both parameters.

4.3.1. Concentrations

For each chemical parameter similar graphs and calculations were performed as for quantities (Chapter 4.2). Due to the extensive dataset only time course graphs and some general statistics are reported here. The time courses of analysed chemical parameters can be found in **Annex 9**.

In Fig. 9 an example of such a time course is presented. In the upper part of the figure are values for the harmonized collectors and in the lower part for the national collectors.

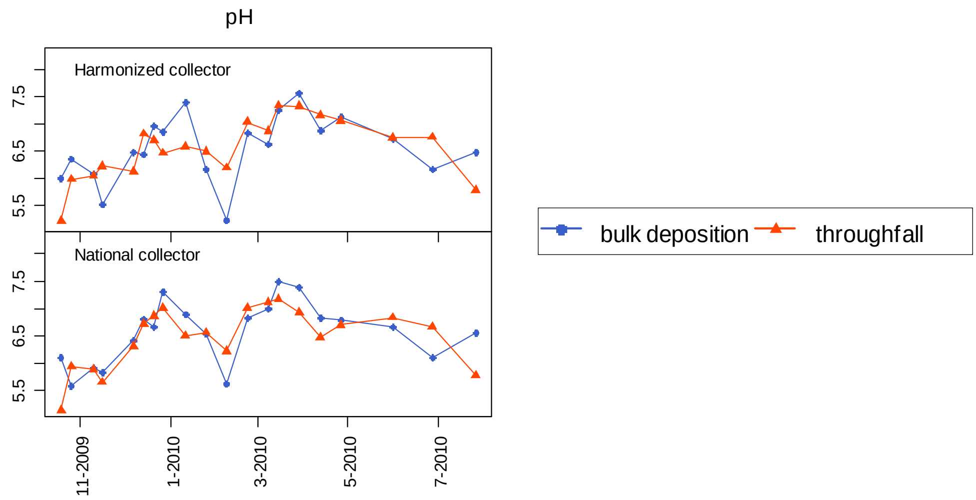

Fig. 9: Example of the time course of pH values for harmonized and national collectors.

Table 4 presents the median relative deviation of concentrations for chemical parameters between the national and harmonized throughfall collectors of the associated beneficiaries. One fifth of the medians are higher than 30% in both negative and positive directions. The majority of the deviations were for pH measurements, alkalinity and chloride. pH and alkalinity were earlier observed to be dependent on the collector type (Bleeker et al., 2003). Even though the deviations were quite high, the absolute values were low and therefore the high deviation in concentrations does not necessarily lead to important differences in the deposition (Chapter 4.4).

Absolute median deviations were much lower for bulk (Table 5) than for throughfall collectors. Again, pH and alkalinity, as well as phosphate in this case, were the parameters where the largest deviations were reported. For conductivity, calcium, magnesium, chloride, sulphate and DOC the median deviation did not exceed 30%. More than half of the median deviations were lower than 10% and 14% were higher than 30%. If the optional parameter phosphate was omitted the percentage was even lower (11%).

Table 4: Median deviation (in %) of concentrations of chemical parameters between national and harmonized throughfall collectors for sample plots of all associated beneficiaries. Cond = conductivity

Ass. Ben.	H^+	Cond	Alk	Ca^{2+}	Cl^-	DOC	K^+	Mg^{2+}	Na^+	N-NH_4^+	N-NO_3^-	N_{tot}	PO_4^{3-}	SO_4^{2-}
02	-14.9	-20.9	-26.2	-33.9	-28.4		-27.9	-33.3	-31.5	-5.9	-43.8	-26.2	246.3	-21.4
03	-46.2	10.9	40.7	26.7	12.2	12.0	10.5	17.1	13.1	15.7	-0.7	12.8	38.5	8.4
07	-59.7	19.2	-66.7	13.4	30.1	2.4	22.3	4.0	54.7	25.8	16.5	22.6		9.4
09	-36.9	-37.5	-42.9	-52.0	-37.5	-74.1	-62.5	-28.6	-25.0	100.0	0.0	25.0		-10.0
10	-71.3	39.2		7.4	13.8	-8.8	-1.2	2.9	20.0	404.2	36.4	115.4		3.7
11		-38.4		-43.1	-33.3	-43.7	-32.7	-36.5	-28.7	-28.4	-23.1	-24.2		-20.3
12	-13.8	-2.6	5.4	-3.2	2.1	0.1	5.6	0.0	-2.3	-25.9	-64.2	-26.2		-20.1
13	0.0	18.9	25.7	3.1	-7.2		19.1	5.3	1.4	3.2	17.0	5.0		5.7
14	-12.9	-8.1	-15.0	-7.8	-9.6		-11.5	-13.0	-10.2	-5.6	-4.5	-17.0	-32.1	-10.9
18	-22.9	-2.1	35.0	-5.9	-5.3	-10.2	12.2	1.5	-4.2	9.2	12.3	0.5	25.4	-2.8
21	-12.9	9.2	4.0	17.6	7.9	5.8	8.0	6.5	-7.2	23.1	5.9	11.5		5.6
22	-42.3	-12.8	85.4	-16.7	-63.6	-5.7	-4.9	-6.2	-16.5	-15.8	-8.4	-8.1		-2.6
23	-12.9	-25.9	-1.8	-28.3	-30.2		-30.7	-26.2	-28.6	-0.6	-29.3			-27.9
26	26.2	11.9	8.9	-4.1	12.0	26.3	27.3	7.9	12.0	20.8	-20.3	10.7	48.7	7.8
30	22.0	0.1	-15.1	2.6	-1.2	4.1	-5.6	5.3	-5.3	-3.9	-4.2	-4.3	0.0	-4.9
40	-5.1	-5.6	-1.4	0.8	-5.3	-18.5	-12.7	-13.0	3.1	-11.2	-2.6	-10.1	0.0	-4.6
Mean	27.6	16.5	27.1	16.6	19.0	18.1	18.4	12.7	16.1	43.5	18.4	21.3	74.9	10.6
SD	19.9	12.8	25.1	15.8	16.8	21.6	15.3	11.9	14.5	99.0	18.0	27.5	135.8	8.0
Min	0.0	0.1	1.4	0.8	1.2	0.1	1.2	0.0	1.4	0.6	0.0	0.5	0.0	2.6
Max	71.3	39.2	85.4	52.0	63.6	74.1	62.5	36.5	54.7	404.2	64.2	115.4	246.3	27.9

Table 5: Median deviation (in %) of concentrations of chemical parameters between national and harmonized bulk collectors for sample plots of all associated beneficiaries. Cond = conductivity

Ass. Ben.	H^+	Cond	Alk	Ca^{2+}	Cl^-	DOC	K^+	Mg^{2+}	Na^+	N-NH_4^+	N-NO_3^-	N_{tot}	PO_4^{3-}	SO_4^{2-}
02	5.9	-5.7	-16.4	-23.3	-10.9		11.1	-23.0	-18.0	13.2	-42.1	-15.6	-42.9	-4.0
03	-3.4	2.5	2.0	13.8	4.0	3.7	-3.8	9.0	5.1	4.5	0.7	1.1	-50.0	6.5
07	-30.9	8.1	-83.4	-16.6	26.5	-0.4	-14.3	-14.5	52.2	-8.2	-20.6	15.4		-5.4
09														
10	-63.6	23.9		-7.6	4.5	3.1	28.6	14.3	17.4	80.6	4.3	34.4		9.1
11		8.2		9.4	4.3		25.0	4.5	13.0	-19.2	11.3			12.5
12	-6.6	-10.9	24.8	-4.6	-22.9	-7.0	-11.0	-11.7	-10.7	-34.9	-55.9	-34.4		-10.5
13	58.5	-20.9	-17.9	-59.7	-14.2		12.1	-30.9	-0.6	38.9	-7.7	8.2		-11.8
14	-6.7	0.0	53.0	6.8	0.0		16.7	5.3	4.4	6.2	3.4		320.0	0.0
18	-30.1	1.9	25.1	3.7	-3.0	-26.4	4.8	21.4	-1.1	10.4	-2.0	-6.0	79.5	-2.1
21	-25.8	1.1	0.0	4.2	-14.3	-3.2	-0.7	19.0	-1.1	9.4	0.0	0.0		1.3
22	21.5	-6.9	-32.9	-4.2	-0.5	13.8	-13.3	-6.5	-6.9	-11.2	3.1	0.1		-1.8
23	-61.5	9.1	71.1	-29.9	-5.2		5.6	-10.0	-10.8	144.9	-7.5			-10.7
26	-20.4	-6.6	-20.2	-15.3	-7.9	-19.7	30.0	-2.5	-3.6	-0.6	-4.6	-1.5	70.0	-8.9
30	10.2	3.2	-92.6	-0.5	-3.2	-6.6	-5.9	13.3	-6.1	1.9	5.7	-1.6	0.0	-1.4
40	-2.3	-0.4	-5.8	13.6	0.0	9.9	75.0	-9.8	11.0	-8.0	0.5	-0.7	0.0	-3.4
Mean	24.2	6.7	31.8	14.2	8.1	9.2	17.9	13.5	11.0	26.1	9.6	8.4	80.9	5.9
SD	21.3	7.1	31.0	14.9	8.2	7.9	18.3	8.5	12.9	38.8	14.1	12.3	109.9	4.3
Min	2.3	0.0	0.0	0.5	0.0	0.4	0.7	2.5	0.6	0.6	0.0	0.0	0.0	0.0
Max	63.6	23.9	92.6	59.7	26.5	26.4	75.0	30.9	52.2	144.9	55.9	34.4	320.0	12.5

The coefficient of determination (R^2) is not a proper indicator of agreement between methods but in the case of high R^2 values it can make the calibration of methods possible (using the OLS regression equation). R^2 also indicates the scatter of data around the regression model. The R^2 values were quite uneven across associated beneficiaries and for different chemical parameters and no clear pattern in scatter magnitude could be revealed. Generally, larger scatter was found for throughfall data than for bulk precipitation data. For the majority of chemical parameters the highest R^2 was found for beneficiary 03 for both bulk and throughfall (Tables 6 and 7).

Table 6: Coefficient of determination (R^2) for the relationship between throughfall concentrations measured using national and harmonized collectors. Cond = conductivity

Ass. Ben.	H^+	Cond	Alk	Ca^{2+}	Cl^-	DOC	K^+	Mg^{2+}	Na^+	$N\text{-}NH_4^+$	$N\text{-}NO_3^-$	N_{tot}	PO_4^{3-}	SO_4^{2-}
02	0.05	0.67	0.79	0.75	0.59		0.42	0.66	0.67	0.73	0.65	0.79	0.01	0.16
03	0.47	0.99	0.73	0.98	0.99	0.92	0.99	0.99	0.99	0.96	0.99	0.96	1.00	0.98
07	0.19	0.29	0.24	0.21	0.24	0.00	0.87	0.04	0.00	0.14	0.54	0.07		0.35
09	0.01	0.39	0.00	0.54	0.76	0.10	0.18	0.24	0.47	0.05	1.00	0.64		0.97
10	0.03	0.99		0.91	0.97	0.88	0.89	0.89	0.81	0.70	0.81	0.94		0.94
11		0.92		0.89	0.29	0.27	0.72	0.76	0.49	0.28	0.03	0.79		0.92
12	0.94	0.92	0.90	0.90	0.07	0.68	0.75	0.81	0.83	0.01	0.10	0.90		0.23
13	0.16	0.57	0.13	0.06	0.00		0.92	0.39	0.15	0.48	0.18	0.35		0.37
14	0.43	0.87	0.57	0.64	0.89		0.60	0.78	0.90	0.70	0.98	0.80	0.24	0.94
18	0.97	0.95	0.34	0.97	0.99	0.96	0.88	0.94	0.98	0.96	0.97	0.94	0.69	0.99
21	0.20	0.83	0.42	0.44	0.48	0.86	0.84	0.67	0.21	0.42	0.03	0.44		0.62
22	0.75	0.93	0.92	0.66	0.31	0.98	0.99	0.95	0.71	0.97	0.97	0.98		0.98
23	0.10	0.77	0.49	0.92	0.57		0.91	0.94	0.90	0.19	0.45			0.39
26	0.95	0.55	0.71	0.47	0.88	0.73	0.74	0.56	0.94	0.58	0.98	0.83	0.76	0.37
30	0.90	0.95	0.78	0.95	0.94	0.97	0.97	0.91	0.78	0.97	0.96	0.97	1.00	0.99
40	0.83	0.97	0.90	0.93	0.92	0.91	0.96	0.90	0.89	0.64	0.91	0.84	0.30	0.89

Table 7: Coefficient of determination (R^2) for the relationship between bulk concentrations measured using national and harmonized collectors. Cond = conductivity

Ass. Ben.	H^+	Cond	Alk	Ca^{2+}	Cl^-	DOC	K^+	Mg^{2+}	Na^+	$N\text{-}NH_4^+$	$N\text{-}NO_3^-$	N_{tot}	PO_4^{3-}	SO_4^{2-}
02	0.11	0.16	0.02	0.39	0.08		0.16	0.63	0.78	0.01	0.01	0.02	0.23	0.04
03	0.80	0.99	0.93	0.98	0.99	0.48	0.94	0.97	0.97	0.91	0.96	0.86	0.99	0.99
07	0.69	0.31	0.24	0.71	0.05	0.52	0.82	0.72	0.05	0.17	0.71	0.04		0.80
09														
10	0.52	0.29		0.92	0.83	0.94	1.00	0.91	0.99	0.77	0.73	0.20		0.98
11		0.99		0.83	0.85		0.73	0.61	0.84	0.96	0.97			0.99
12	0.50	0.87	0.92	0.81	0.36	0.25	0.16	0.76	0.92	0.88	0.58	0.88		0.37
13	0.26	0.78	0.04	0.58	0.35		0.09	0.55	0.32	0.54	0.35	0.55		0.35
14	0.73	0.95	1.00	0.82	0.97		0.47	0.97	0.97	0.92	0.95			0.90
18	0.97	0.05	0.15	0.72	0.98	0.01	0.93	0.15	0.97	0.16	0.99	0.14	0.38	0.77
21	0.00	0.36	0.48	0.28	0.21	0.84	0.82	0.30	0.39	0.18	0.68	0.23		0.58
22	0.07	0.42	0.30	0.67	0.92	0.38	0.36	0.87	0.93	0.77	0.99	0.72		0.96
23	0.74	0.69	0.69	0.96	0.64		0.49	0.76	0.73	0.47	0.98			0.64
26	0.95	0.85	0.00	0.99	0.99	0.49	0.94	0.97	0.95	0.72	0.96	0.31	0.04	0.99
30	0.64	0.56	0.25	0.90	0.97	0.48	0.14	0.48	0.88	0.77	0.76	0.84	0.80	0.59
40	0.79	0.96	0.60	0.41	0.82	0.43	0.05	0.45	0.73	0.70	0.83	0.80	0.06	0.90

4.3.2. Deposition

The deposition values were calculated in g m^{-2} yr^{-1} (to get the values in kg ha^{-1} yr^{-1} a multiplication by 10 should be made) (Figs. 10, 11 and 12). The value in some cases is not really per year since the snow period was excluded. In such cases the values are extrapolated to the value of one year. The real sampled days are the same as presented in Fig. 7.

Graphic presentation for each mandatory parameter for deposition measurements can be found in **Annex 10**. In this part three of them are discussed.

For ammonium-nitrogen the order of magnitude was in accordance between the different types of collectors. Only the measurements performed by associated beneficiary 18 showed a considerable difference (twice as much) between the harmonized and national bulk precipitation collectors. In a cross-check with the alkalinity and electroconductivity, a higher amount of ammonium was indeed present. In combination with higher values for phosphate we assumed a contamination of the samples in the harmonized collectors by bird droppings. A difference of around 0.3 g m^{-2} yr^{-1} of ammonium-nitrogen was found for beneficiaries 07, 10 and 23, for all three with higher deposition in the harmonized collectors but for 7 and 10 in the throughfall deposition, and for 23 in bulk deposition. For all other associated beneficiaries the difference in deposition of ammonium-nitrogen was in all cases lower than 0.3 g m^{-2} yr^{-1}.

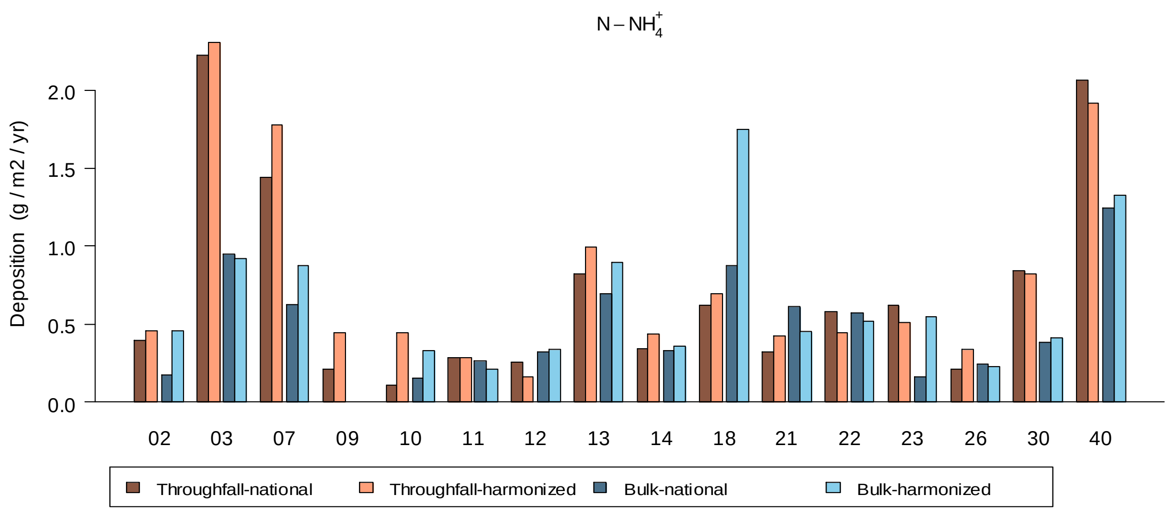

Fig. 10: Deposition of ammonium-nitrogen (g m^{-2} yr^{-1}) in bulk precipitation and throughfall in both national and harmonized collectors.

The deposition of nitrate-nitrogen showed smaller differences between the national and harmonized collectors. The biggest differences are noticed for associated beneficiaries 07 and 13 (0.2 - 0.3 g m^{-2} yr^{-1}) where more nitrate was found in the harmonized throughfall collectors. In all other cases of throughfall nitrate-nitrogen deposition the differences between national and harmonized collectors were lower than 0.1 g m^{-2} yr^{-1}.

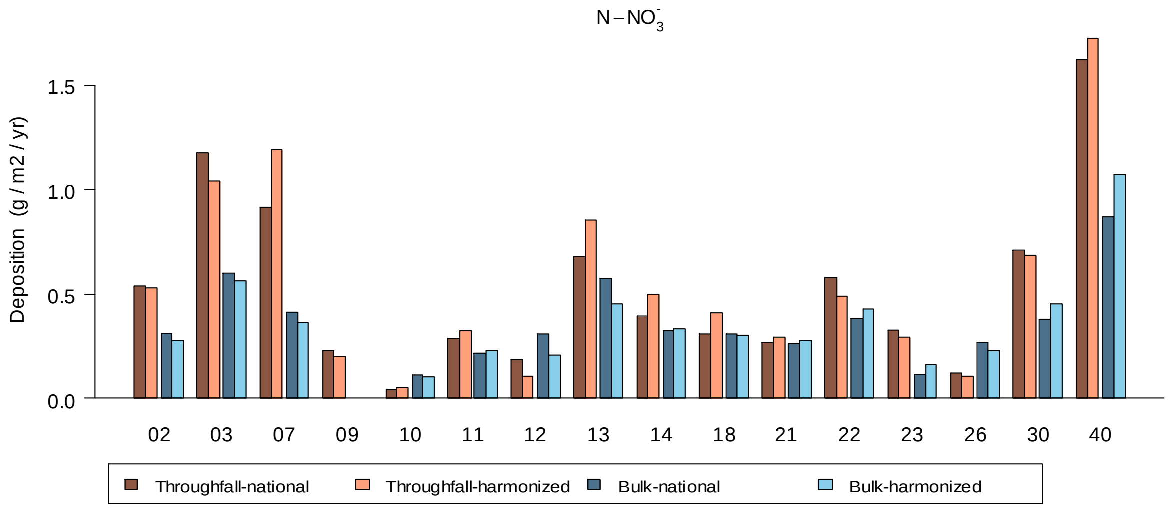

Fig. 11: Deposition of nitrate-nitrogen (g m^{-2} yr^{-1}) in bulk precipitation and throughfall in both national and harmonized collectors.

For sulphate-sulphur good agreement was found (Fig. 12) for most associated beneficiaries except for associated beneficiaries 12 (bulk and throughfall, just over 0.3 g m^{-2} yr^{-1}) and 13 (bulk only, 0.25 g m^{-2} yr^{-1}). Since the quantities of different types of collectors were in good agreement in the case of both associated beneficiaries, the cause for the difference could be related to the material of both types of collectors where one could be more efficient in capturing dry deposition than the other.

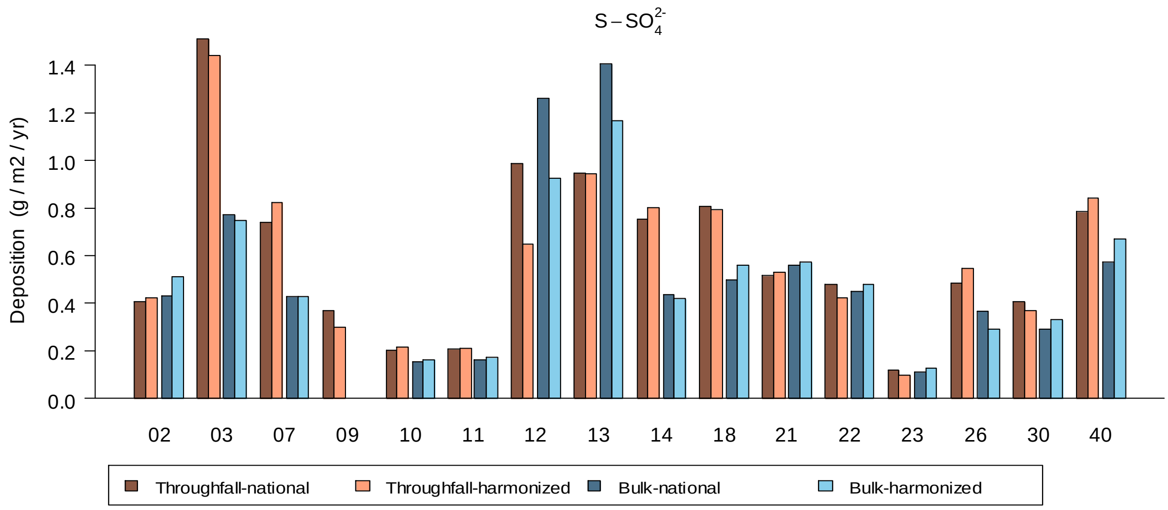

Fig. 12: Deposition of sulphate-sulphur (g m^{-2} yr^{-1}) in bulk precipitation and throughfall in both national and harmonized collectors.

The calculations for deposition include a cumulative error of volume determination and chemical analysis. Therefore even higher differences were expected. We took sodium as a tracer and we found that there was indeed an increase in fluctuations: 8 out of 15 of the associated beneficiaries reported a difference for sodium deposition of less than 10% for bulk measurements (Table 8). Others were just over 10% and up to 39%. Just three associated beneficiaries reported higher deposition of sodium in the national collectors than in the harmonized ones. Possible reasons for high deviations are differences between the physical and chemical properties of the collectors, including material of the collector, shape, size, surface etc. For chloride similar results were obtained. Associated beneficiaries 2, 7, 26 and 40 differed strongly for these two values with higher deposition in the national collector. Here, dry deposition to the bigger surface of the national collector compared to the harmonized collector could play a role in the cases of associated beneficiaries 2, 7 and 40, although for associated beneficiary 26 this is not the case. Only associated beneficiary 40 reported a higher deposition to the national collector for the whole spectrum of parameters.

Table 8: Deviation in percentage ((harmonized – national))/national * 100) in deposition for bulk collectors. A negative deviation means a higher deposition to the national collector than to the harmonized collector.

Ass. Ben.	Na^+	Cl^-	Ca^{2+}	K^+	Mg^{2+}	DOC	N-NH_4^+	N-NO_3^-	Ntot	SO_4^{2-}	PO_4^{3-}
02	19.8	21.8	-29.6	1.5	-39.1		159.8	-20.7	39.6	16.7	68.2
03	-8.3	-9.3	1.0	-21.5	-0.7	8.5	-3.2	-6.1	3.1	-2.7	-50.0
07	38.9	44.3	-6.3	22.2	0.0	-10.9	27.2	-16.2	46.3	-2.9	
10	2.0	6.3	-2.3	22.4	9.1	-6.1	125.0	-7.8	27.6	3.9	
11	6.3	-4.9	-1.0	14.2	-8.7		-20.5	5.6		4.9	
12	1.8	-34.3	32.2	-6.1	20.2	102.0	-46.7	-66.7	-40.7	-44.2	
13	10.7	-46.4	-47.1	15.5	-35.7		29.1	-21.4	-3.8	-17.0	
14	16.3	-1.2	16.2	27.3	18.1		8.8	3.7		-4.6	
18	2.3	2.3	12.4	53.3	57.4	-30.1	100.4	-2.4	74.3	13.2	168.4
21	-10.8	16.7	9.2	76.5	31.3	15.6	-26.0	4.5	-11.3	2.5	
22	3.0	7.0	-0.9	-7.1	-1.4	21.0	-9.0	11.8	-9.4	6.0	
23	3.2	3.1	-17.4	64.4	28.6		238.0	38.8		16.7	
26	-25.9	-27.7	-29.0	2.7	-24.9	-33.1	-5.4	-13.8	194.5	-20.4	3200.0
30	2.2	5.5	18.5	17.8	36.4	-6.6	5.8	22.4	9.3	16.1	52.9
40	31.8	24.8	25.6	56.7	9.0	29.3	6.9	23.3	13.9	17.6	30.7

The deviations for throughfall were generally higher than for bulk precipitation (Table 9). The influence of placement of the collector in relation to the tree stems played a significant role on the deviation of measurements. Deposition of sodium in the forest stand was much more dispersed than in bulk precipitation. 14 out of 16 associated beneficiaries had deviations which were over 10%. Whether or not the harmonized collectors were placed independently or dependent on the national collectors did not play a significant role for the deposition. Both positive and negative deviations were observed for both types of set-ups.

Table 9: Deviation in percentage ((harmonized – national))/national * 100) in deposition for throughfall collectors. A negative deviation means a higher deposition to the national collector than to the harmonised collector.

Ass. Ben.	Na^+	Cl^-	Ca^{2+}	K^+	Mg^{2+}	DOC	$N\text{-}NH_4^+$	$N\text{-}NO_3^-$	Ntot	SO_4^{2-}	PO_4^{3-}
02	18.3	-3.8	-5.2	6.5	-4.6		13.2	-1.8	4.7	4.9	566.7
03	-3.4	-2.6	2.8	-6.8	-1.6	0.6	3.6	-11.4	-1.5	-4.6	-17.6
07	55.3	25.8	2.6	14.4	-3.4	-6.5	31.6	40.5	27.9	5.8	
09	-46.1	-46.1	-60.1	-69.9	-41.6	-77.9	109.6	-10.6	21.6	-19.6	
10	17.3	18.4	5.4	-0.6	4.8	-9.7	297.8	23.5	127.9	2.8	
11	-20.1	-16.3	-25.0	-12.0	-24.9		0.0	11.9		2.9	
12	28.7	11.3	-5.5	-14.7	4.0	-38.9	-43.6	-53.0	-39.4	-26.1	
13	12.9	-23.2	-15.8	26.3	-7.4		21.2	25.8	29.8	-0.1	
14	25.5	15.2	30.0	34.1	23.4		28.4	27.1		6.1	
18	-2.5	-4.8	-3.7	7.9	-1.2	-9.8	13.0	32.7	7.0	-1.7	45.5
21	-38.5	21.4	12.5	-3.1	4.5	3.0	30.1	10.0	16.9	2.3	
22	-31.0	-60.8	-21.2	-19.3	-16.7	-20.7	-23.8	-16.4	-16.7	-12.0	
23	-23.4	-25.2	-21.3	-15.7	-18.3		-18.1	-9.6		-18.5	
26	24.5	23.9	-2.3	30.0	6.8	27.5	62.0	-9.9	27.3	12.3	45.8
30	-12.5	-10.9	-7.1	-8.1	-7.7	5.6	-1.5	-5.2	-3.2	-11.3	-5.9
40	22.2	14.1	10.8	-4.0	2.6	-13.1	-4.0	9.7	1.9	9.6	22.3

Dot plots for all associated beneficiaries show good agreement in total deposition (in g m^{-2} $year^{-1}$) of different chemical parameters between national and harmonized collectors. Data labels represent beneficiary codes. R^2 values are also presented (Fig. 13). For other chemical parameters the figures can be found in **Annex 11**.

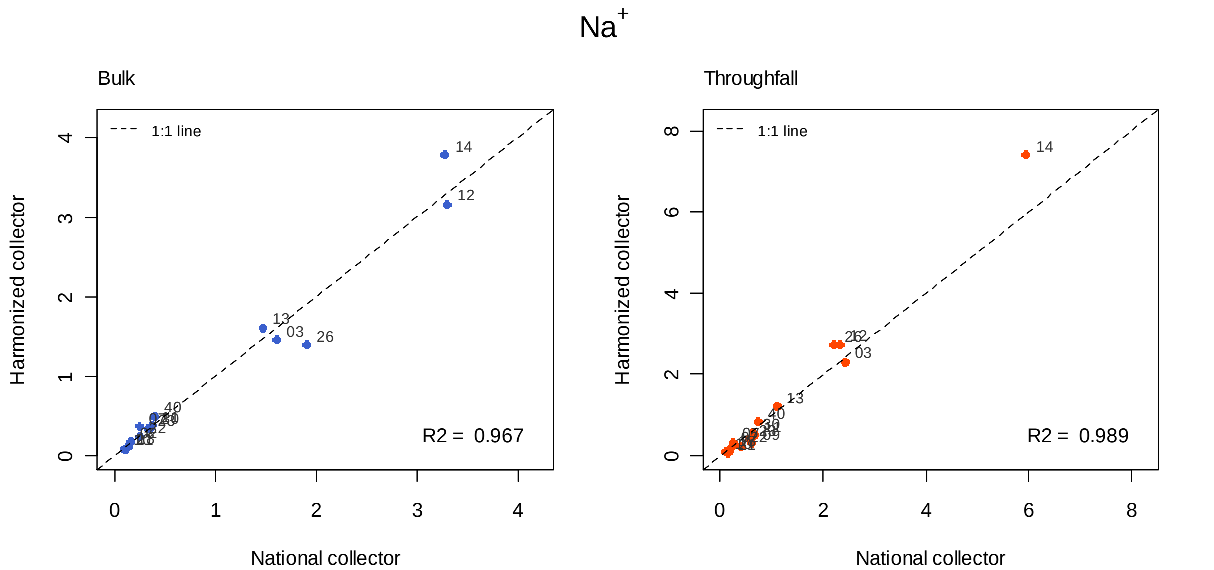

Fig. 13: Agreement between national and harmonized collectors in bulk and throughfall deposition of sodium.

5. Summary and conclusions

The main task of the C1-Dep-22(SI) action was to compare national throughfall collectors with a harmonized collector which was designed according to the requirements of the WMO. The action took place in different climate zones and vegetation, and included different types of national collectors with different sampling procedures. The number of harmonized throughfall collectors was 30 for all associated beneficiaries. The spatial arrangement in the plot, sampling times, sampling and cleaning procedures, bulking of the subsamples and chemical analysis procedures were in all cases the national procedures. The time when the precipitation was in the form of snow was excluded from the sampling periods. The associated beneficiaries reported the amounts of precipitation per collector and the results from chemical analysis per pooled sample.

The measured quantities were compared for different types of forest or main tree species. The deviations between collectors were lower in the plots with broadleaf trees than in the plots with conifers as the main tree species. The median deviations for conifers and for broadleaves is not significantly different from zero.

Except in a few cases, good agreement in the amount of precipitation was found between the national and harmonized collectors for both throughfall and bulk precipitation. We assume that where this was not the case, this was due to extreme weather conditions e. g. heavy storms.

Good agreement was also found for the chemical composition of the solutions gathered with different types of collectors. Again, there were some deviations limited to single occasions. It was found that the white-coloured harmonized collectors attracted birds and thus a bird ring is a must in this version of the collector.

Deposition values of ammonium-nitrogen, nitrate-nitrogen and sulphate-sulphur were compared in detail. For ammonium-nitrogen no big difference was found for the one-year deposition values except in one case which turned out to be almost certainly a consequence of bird activity. Differences in all other cases were no more than 0.3 g m^{-2} yr^{-1}. For nitrate-nitrogen smaller deviations were found but the difference in total annual deposition was never higher than 0.3 g m^{-2} yr^{-1}. For sulphate-sulphur good agreement was found for all associated beneficiaries except two. The difference in the ability of the collectors to collect dry deposition and/or the total surface area where dry deposition could be captured may be possible reasons for the disagreement.

To improve the harmonized collector even more, problems with possible blockages of the tube at the bottom of the funnel because of debris should be solved. This includes installing a better functioning filter.

Despite their heterogeneity and some lack of adaptation for representative sampling at the plot scale, the national devices for throughfall collection used in ICP Forests monitoring programme gave comparable results for throughfall deposition to the harmonized, optimal collectors. In conclusion, national throughfall collection devices can be maintained to ensure the continuity of the time series in deposition monitoring throughout Europe.

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7. Annexes

Annex 1: Minutes of the EPD meeting in Hamburg, 2009

European Union / United Nations Economic Commission for Europe International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests

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12th Meeting of the Expert Panel on Deposition
(15 – 16 January 2009, Hamburg, Germany)

Minutes of the meeting

1. The minutes of the 11th Meeting of the EPD in Madrid (29 September – 1 October 2008) were read and approved.

2. Planning of the deposition-related activities in the FutMon project was done. Deposition-related activities will be carried out in Actions IM1/C1-DEP-22(SI), and deposition monitoring will also contribute to Actions D2 and D3. The main discussions concerned the standardised sampler comparison in Actions IM1 and C1-DEP-22(SI), and the following conclusions were made:

i. The comparison will be done using both bulk and throughfall rain samplers, but not snow samplers.

ii. The number of samplers will be 30 for throughfall and 3 for bulk deposition.

iii. Plot size should be according to the manual, but plot structure varies between countries. A combined systematic/random distribution of standard samplers should be used (see Fig. 4 in the proposed revision of the manual). It is recommended to set up the harmonised samplers in the buffer zone of the plot.

iv. Sampling frequency will be according to the national system.

v. Pooling of samples will unfortunately be necessary because of the costs of analysing individual samples. This will give one throughfall sample and one bulk sample per sampling occasion for both the national and the harmonised samplers. Volume-weighted pooling (if this should be necessary) can be carried out in either the field or the lab, using either weights or volumes. More detailed instructions for pooling will be sent out.

vi. The harmonised sampler should be constructed according to what is written in the Manual ("The sampling equipment should consist of a funnel and a receiving vessel. The material used for the collector should be high density polyethylene. The sampling area should be horizontal and the upper part of the sampler vertical. The surface of the collector must be smooth. The height of the sampling surface should be 1 m above ground level. An inert sieve with a mesh size of 1 mm should be placed loosely at the top of the neck of the sampler. Sample containers should be kept cool and in the dark"). It should have a bird ring. The diameter will be 16 cm, not 20 cm. The storage container will be 4 l, and placed in the ground if this is possible. The height of the samplers above ground level will be 1 m for both throughfall and bulk samplers. Fencing will be according to the national system.
vii. Cleaning of the sampler and storage container will be according to the national system.
viii. Timetable: equipment should be ordered by 1 March and installed by 31 May.

3. A report on the meeting of the Working Group on QA/QC in Laboratories on 13 January 2009 was given by Nils König, including information on the next Working Ring Test for deposition samples to be held in the spring of this year.

4. The proposed revisions to the deposition sub-manual were discussed. Some changes were suggested, mostly to Section 6 (data handling and reports). The list of ISO and CEN methods in Annex 6 will be updated. A new version will be prepared and sent out for comment.

5. Updating of the Annex on canopy budget models is necessary, and will be done later this year.

6. A presentation of results on water quality measurements on the permanent observation plot in Chojnow forest district, Poland, in the years 2004-2007 was given by Anna Kowalska.

7. Anna Kowalska presented Polish data on between-sampler variation in chemical composition, for both concentrations and fluxes.

8. Revision of the data quality indicators of the EPD was discussed.
The EPD has currently 10 QA/QC indicators (1 (i) about the number of the labs in the Working Ring Tests (WRTs), 6 (ii-vii) about lab quality, 2 (viii-ix) about field quality, 1 (x) about evaluation). The following changes are proposed:

i. *Number of participants at the WRTs and the discussion meeting of the WRT results.* This is quantifiable. Participation in WRTs is mandatory in FutMon, but not for laboratories not participating in FutMon, so this is still relevant.

ii. *Number of countries helped on how many parameters by the working group on QA/QC in labs.* This indicator is ambiguous and may be omitted.

iii. *Number of labs (in % of total) getting better/worse in WRTs.* Omit.

iv. *WRT results: % of laboratories which perform all the mandatory measurements.* This is quantifiable, although there may be changes in mandatory parameters. Replace with '% of laboratories that have met the benchmark criteria'.

v. *% of outlier results for mandatory parameters*. This indicator is quantifiable, but write '% of results within the tolerable limits'.

vi. *% of labs using mean control charts for all parameters.* This indicator is quantifiable and will be retained unchanged.

vii. *% of results at the Working Ring Tests within the target of the Data Quality Objectives.* This is in principle similar to (v), so it can be omitted as a separate indicator.

viii. *Number of plots for which studies on spatial arrangement combined with calculations of the needed number of samplers exist.* This indicator is not relevant for FutMon, although still relevant for ICP Forests.

ix. *Number of plots with the necessary number of samplers installed for throughfall measurements to reach the target level.* This indicator is not relevant for FutMon, although relevant for ICP Forests.

x. *Number (%) of plots for which regular <u>total deposition estimates + indication of which methods are used</u> are done annually for all measured ions.* This indicator is relevant, but replace 'all measured ions' with 'components relevant for acidification and nutrient fluxes'.

Conclusion: indicators (i), (iv), (v), (vi) and (x) will be used in both FutMon and ICP Forests, and indicators (viii) and (ix) in ICP Forests.

9. Changes in the reporting forms were discussed. The PLD forms will be retained. It was suggested that the DEM and DEO forms could be combined.

10. It should be possible to include information on the completeness of the submitted data in the reporting. Simplest would be to use a system of codes giving the various reasons for

missing/adjusted/estimated data in the database (e.g. contamination, no precipitation, not enough precipitation to make all the analyses, destruction of the sampler, sampling not performed, overflow). If an estimated value is reported, this should be noted, together with information on how the estimate was made.

Annex 2: Invitation, 2009

GOZDARSKI INŠTITUT SLOVENIJE

Slovenian Forestry Institute
Večna pot 2, 1000 Ljubljana, Slovenija
tel: + 386 (0)1 200 78 00 / fax: + 386 (0)1 257 35 89

Date: 9. 3. 2009

I N V I T A T I O N

"Harmonizing deposition samplers – action C1-Dep-22(SI)"

Dear colleagues in FutMon project!

According to Strategy for the Expert Panel on Deposition 2006-2009 (http://www.icp-forests.org/DocsDepo/Rovan05_activities_2006-2009.doc), minutes of the Expert Panel on Deposition meeting at Kick-off meeting in Hamburg (January 2009) (http://www.icp-forests.org/DocsDepo/Depo_HH_minutes_2009.pdf) and FutMon program (LIFE+ 07ENV/D/00218) we are responsible for organizing the production and distribution of the harmonized samplers and collecting the results and sending them to the coordinating beneficiary. Here we would like to invite you to send the necessary data listed below for further progress of the action.

Beneficiary no.	Responsible person	Contact person	Institute	Address	ZIP Code / City	Country	E-mail	Phone	Fax

Let us remind you that one plot with the harmonized samplers per country is planned and not one plot per beneficiary!

Further activities and procedures will be sent to the contact persons only!

Best regards,

Daniel Žlindra

Annex 3: Guidelines, 2009

LIFE+ 2007

FUTMON

"Harmonizing deposition samplers – action C1-Dep-22(SI)"

GOZDARSKI INŠTITUT SLOVENIJE

Slovenian Forestry Institute
Večna pot 2, 1000 Ljubljana, Slovenija
tel: + 386 (0)1 200 78 00 / fax: + 386 (0)1 257 35 89

Date: 31. 3. 2009

G U I D E L I N E S

Dear colleagues,

thank you for your responses. The samplers are now ready for production. Contact person for ordering, getting official offers etc. is

Mrs. Simona Škrbec, product manager,
Roto d.o.o.
Gorič-ka 150, Černelavci,
9000 Murska Sobota
Slovenia
Phone: +386 2 52 52 186
Fax: +386 2 52 52 171
e-mail: simona@roto.si
web: www.roto.si
Code: FutMon

The scheme of the sampler and installation of it in the field are enclosed in the attachment. Besides you'll need equivalent numbers of pipes (160 mm) – usual length 3 m, sawing in two parts for two samplers will satisfy. For aeration we recommended drilling some holes in the

upper part of the pipe. The height of the pipe (above the ground) it depends on the inner diameter of the tube and hence how much the funnel sinks in the tube.
The design of the sampler enables to simply screw the container to the funnel. In the case of to worm conditions we recommend wrapping the container in the Al foil or dig it in the ground and connect funnel and container with the tube (for gardening or similar). In that case you'll need to make proper hole in the stopper (delivered with the container) of the container.

Since we made agreement about the *sampler* design (Hamburg, EPD minutes, 2009) the *sampling* design stayed rather unclear. Due to large differences in sampling layout between countries it is hard to suggest unique and very elaborated design. To meet the main objectives of this action (comparison of sampling methods within a country and between countries) we suggest that:

- the standardized samplers should cover the same reference area as already installed national samplers do,
- the arrangement of the standardized samplers should follow the arrangement of the national samplers (judgment design, systematic-random, subplots, etc.),
- the volumes should be measured separately for each collector,
- although the mandatory number of samples for chemical analysis is one, we recommend that the number of subsamples for chemical analysis should be the same as it is in national system (if 3, then one third of the samplers should be pooled); collectors should be numbered and the same collectors should contribute to the same subsample in all sampling intervals,
- after the installation of the samplers we kindly ask you to send the scheme of positioning of the samplers on the plot with the details of sampling design,
- we recommend that the plot, chosen for the installation of the standardized samplers should be homogenous, typical and representative for the country, if possible: we have in mind that the reduction of the costs is also at great meaning – very accessible plots have priorities. The forest stand should be preserved and undisturbed as much as possible,
- the same procedures for bulk deposition samplers.

As we saw the answers about the bird rings, we propose to leave as are according to national design (which are checked enough). For stopping the litter outside the collector, you can use nylon mesh between the collector and the funnel or aquarium filtering fleece of proper amount in the funnel. If any better solution, please share it with all the others.

As we agreed 30 throughfall and 3 bulk samplers are needed. At ordering please consider (according to national procedures) changing the samplers for cleaning them in the lab which at least doubles the number needed!

If any questions or troubles please don't hesitate to contact me!

Best regards,

Daniel Žlindra

Annex 4: Call for data, 2010

FutMon

"Harmonizing deposition samplers – action C1-Dep-22(SI)"

GOZDARSKI INŠTITUT SLOVENIJE

Slovenian Forestry Institute

Večna pot 2, 1000 Ljubljana, Slovenija

tel: + 386 (0)1 200 78 00 / fax: + 386 (0)1 257 35 89

Date: 13. 7. 2010

Subject: Call for data on FutMon C1-Dep-22(SI) action

Dear colleagues,

With this letter of invitation the Slovenian head of the C1-Dep-22(SI) action asks you for data submission on deposition quantities and results of chemical analysis to perform European-wide calibration/agreement between current national deposition samplers and harmonized samplers.

As agreed in Tampere EPD meeting in February 2010 (see minutes in the web page of FutMon, http://www.futmon.org/documents_events/previous/1002_Tampere/EP_DEPO/01_Minutes_EP_Deposition.pdf):

- four (4) files (two .PLH and two .DEH) should be submitted to vTI database in Hamburg after the end of sampling but not after the 31. October 2010. The protocol for submission is the same as for the regular annually submission of these files to vTI. For submission forms see http://www.futmon.org/data_submission/FutMon_ICPForestsForms2009_V5_2e.doc
- two (2) MS Excel files (with detailed quantities and quality information; C1_Dep_quantities.xls, C1_Dep_chemistry.xls) and one (1) MS Word file (with detailed sampling and design information; DAR-Q-H.doc) should be submitted directly to the associated beneficiary 22 (Slovenia) not later than August 31. 2010 for quantities and DAR files and October 31. 2010 for chemistry. Submission and DAR forms are available on the FutMon web page.

PLH files

The files which contain plot information should be assigned for each year separately. The form is the same as .PLD file. The name of the file should be as follows:

Associated Beneficiary code_year.PLH (- e.g. 22_2009.PLH and 22_2010.PLH for Slovenia)

DEH files

The files which contain the chemical analysis information should be assigned for each year separately. The form is the same as .DEM file. The name of the file should be as follows:

Associated Beneficiary code_year.DEH (- e.g. 22_2009.DEH and 22_2010.DEH for Slovenia)

General notices for Excel and Word files

- data only from the throughfall and bulk samplers are needed
- submit raw data where required
- when additional data from national samplers are not reported to the central database but collected, then submit data of these samplers as well (e.g. additional transects of samplers).
- in Excel files the requested fields are similar (but not the same) as .DEM file reported to the central database

Deposition data – Quantities ("C1_Dep_quantities.xls”)

- each row is one sampler of each (shortest) sampling term of each plot. If there are 15 national and 30 harmonized samplers on the plot there will be 45 rows for one sampling term for each plot.
- the column "Pairing" is intended for cases when there are dependent samplers (harmonized and national samplers in groups close to each other – see DAR for details). With letters "a", "b", "c" etc. the groups of samplers are specified. In case of independent samplers this column should be left blank.

Deposition data – Chemistry (“C1_Dep_chemistry.xls")

- each row is one chemically analyzed sample, which was pooled from certain number of samplers of each sampler type (bulk/throughfall) and model (national/harmonized) in a sampling period. If 30 harmonized throughfall samplers are pooled 15 by 15, there will be 2 rows for chemistry data for each sampling time period for the throughfall/harmonized type of samplers.
- in a column “ID's of pooled samplers“ all sampler ID’s should be listed which contribute to the pooled sample for chemical analysis, e.g. the first fifteen harmonized samplers are pooled in one sample for chemical analysis, then fill in: “1,2,3,4,5,6,7,8,9,10,11,12,13,14,15”. Mind the consistency with the labels of samplers in the figure!
- it contains only mandatory parameters (and phosphorus in addition). If some parameters were not measured, those columns should remain blank

DAR (“DAR-Q-H.doc”)

- in DAR – photos and figures with sampler arrangement and sampler ID's are strongly recommended

In case of any question please do not hesitate to contact:

daniel.zlindra@gozdis.si or daniel.zlindra@gmail.com

Your Sincerely,

Daniel Žlindra, Head of the C1-Dep-22(SI) action

Annex 5: DAR-Q, 2010

Data Accompanying Report on Deposition Harmonisation Action

Country name: Country no.: Associated Beneficiary no.:

The action is performed in plot no.

Dominant tree species:

Stand age:

Sampling layout and equipment

The number and location of the samplers under the canopy:

	kind of samplers (funnel / gutter /other – specify)	in the plot	in the buffer zone	outside the plot	other, observations
National throughfall samplers					
Harmonized throughfall samplers	funnel				

Throughfall samplers are placed (add figure and photos!)

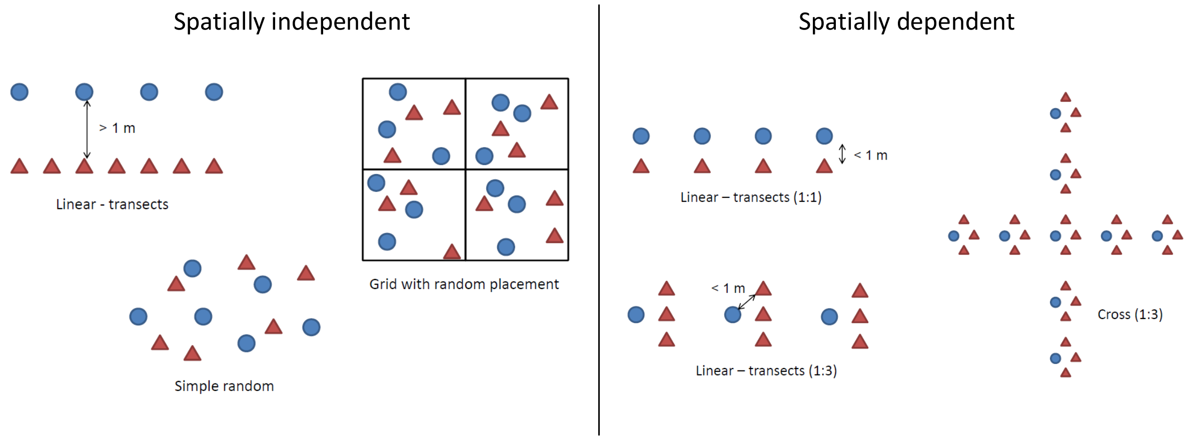
- ☐ Using a line with fixed distances of meters
- ☐ Using a line with randomised distances
- ☐ Using a line-cross with fixed distances of meters
- ☐ Using a line-cross with randomized distances
- ☐ Using a sampling grid
- ☐ At random
- ☐ In another way:

Spatial dependency of the samplers (refers to proximity of national and harmonized samplers)[1]

☐ Samplers spatially dependent (in pairs or 1:2 or 1:3 in close proximity)

☐ Samplers spatially independent (not in pairs, several meters apart)

Examples of independent and dependent sampler arrangement:



The number and location of the bulk samplers:

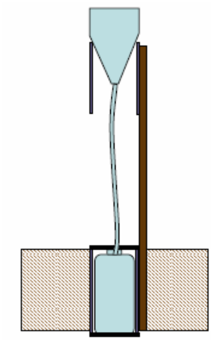
Approximate distance from the throughfall measurements: m.

	kind of samplers (funnel/gutter/other – specify)	number of samplers	height of the samplers	other, observations
National bulk samplers				
Harmonized bulk samplers	funnel	3		

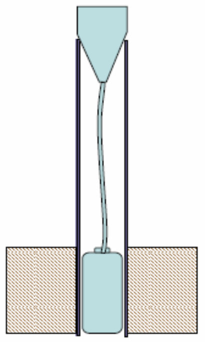
Sampler set-up

[1] If harmonized and national samplers are located in pairs in close proximity (within 1 m average distance) then we may regard these samplers spatially dependent (paired) which calls for different statistical tests.

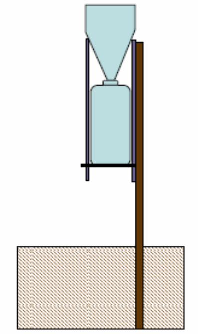
Suggestion 1:



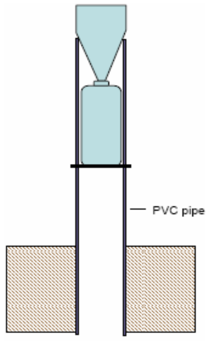
Suggestion 2:



Suggestion 3:



Suggestion 4:



How are samples mounted:

☐ Suggestion 1, specify:

☐ Suggestion 2, specify:

☐ Suggestion 3, specify:

☐ Suggestion 4, specify:

☐ In another way:

Was a bird ring used?

☐ Yes, own design, specify and send a picture:

☐ Yes, UK design as send around:

☐ No :

Were other measurements performed:

☐ Temperature in air, specify method:

☐ Temperature in sample, specify method:

☐ Light, specify method:

☐ Other, specify:

Frequency of sampling

	measured from dd/mm/yy	measured until dd/mm/yy	Frequency

National throughfall samplers	/ /	/ /	every weeks
Harmonized throughfall samplers	/ /	/ /	every weeks
National bulk samplers	/ /	/ /	every weeks
Harmonized bulk samplers	/ /	/ /	every weeks

There was snow (not measuring) period: from / / until / /

Volume determination

Determination of the volume of the sampler solution was carried out for:

☐ All samplers individually:

☐ Part of samplers, specify:

How?

☐ By weight:

☐ Measuring volume with measuring cylinder:

☐ Other, specify:

Describe procedure in case of overflow:

Protection against contamination

Measures were taken to protect the samplers against: (more than one answer is possible, please, add pages if necessary)

☐ Litterfall: specify

- ☐ Using Slovenian filter
- ☐ Using own filter, specify material and mesh size
- ☐ Using no filter

☐ Bird droppings: specify

☐ Animals: specify

☐ Algae growth

  ☐ Containers are protected against light

  ☐ Containers are protected against heat

  ☐ Preservatives are used against algae growth, specify:

  ☐ Other:

☐ Other, specify (cleaning, and similar):

How is contamination of the sampler solution prevented?

☐ By rinsing the samplers after each sampling period

☐ By removing algae in the sampler containers after each sampling period

☐ By using new plastic bags inside the container for each sampling period

☐ Other, specify:

What protection measures have been taken against contamination of the samples?

- To avoid contamination by multiple use of measuring equipment:
- To avoid contamination by soil contact:
- To avoid contamination by contact with the hands of the sampling staff (e.g. gloves)
- Other, specify:

Quality control

Samples were rejected in case of (more than one answer is possible):

☐ Algae growth

☐ Bird droppings in the sampling equipment

☐ Damaged sampler

☐ Overflow

☐ Litterfall in funnel

☐ Other visual irregularities, specify:

Transportation and storage

How is the transport organized?

☐ Mail

☐ Car

☐ Train

☐ Other, specify:

How long time does it take between collection in the forest until arrival at the laboratory?

- Average days
- Maximum days

Samples are transported in

☐ Collection container itself

☐ Laboratory bottles

☐ Other transportation medium:

Sample storage

What measures were used to avoid unwanted changes in samples between sampling and analysis? (more answers are possible)

☐ Keeping the samples dark

☐ Keeping the samples cold (temperature between and °C)

☐ Preservatives, specify:

☐ Other, specify:

Samples are stored in:

☐ PE containers

☐ laboratory bottles, material:

☐ other type of container:

Sample preparation / pooling and analysis

Samples from the **national** open-field samplers:

Samples are pooled prior to the analysis:

☐ yes: mixing samples from the same sampling period:

no. of samples per composite sample:

☐ yes: mixing samples from subsequent sampling period, specify:

☐ no

Samples are prepared prior to the analysis:

☐ samples are filtered,

☐ other, specify:

Samples from the **national** throughfall samplers:

Samples are pooled prior to the analysis:

☐ yes: mixing samples from the same sampling period:

no. of samples per composite sample:

☐ yes: mixing samples from subsequent sampling period, specify:

☐ no

Samples are prepared prior to the analysis:

☐ samples are filtered,

☐ other, specify:

Samples from the **harmonized** open-field samplers:

Samples are pooled prior to the analysis:

☐ yes: mixing samples from the same sampling period:

no. of samples per composite sample:

☐ yes: mixing samples from subsequent sampling period, specify:

☐ no

Samples are prepared prior to the analysis:

☐ samples are filtered,

☐ other, specify:

Samples from the **harmonized** throughfall samplers:

Samples are pooled prior to the analysis:

☐ yes: mixing samples from the same sampling period:

no. of samples per composite sample:

☐ yes: mixing samples from subsequent sampling period, specify:

☐ no

Samples are prepared prior to the analysis:

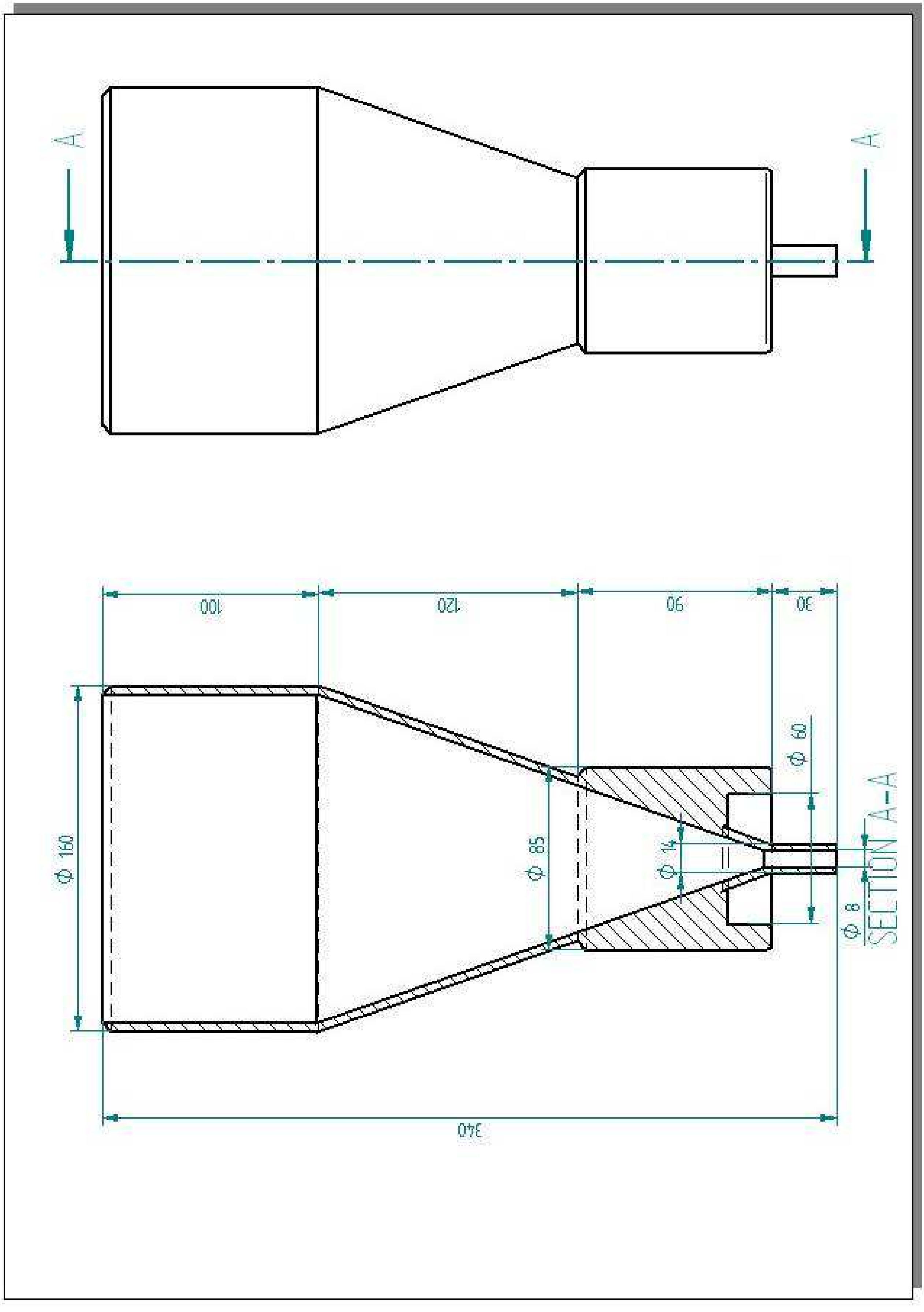
☐ samples are filtered,

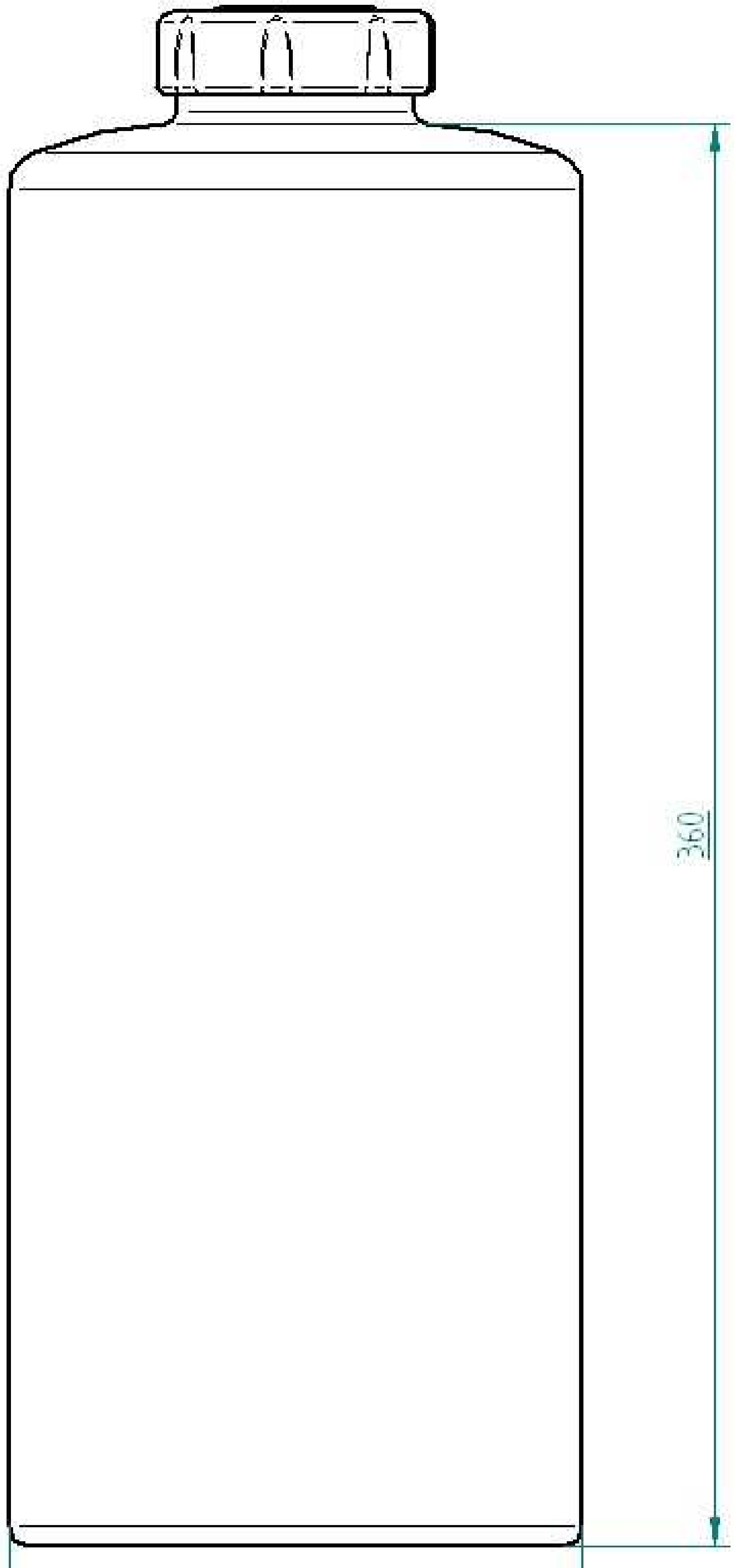
☐ other, specify:

Please, supply photos of your site and the harmonised throughfall sample set-up (preferably with all labels of samplers)!

Photo & figures section:

Annex 6: Sketch of the harmonized collector




360
145

Annex 7: Harmonized sampler

LIFE+ 2007

FUTMON

"Harmonizing deposition samplers – action C1-Dep-22(SI)"

GOZDARSKI INŠTITUT SLOVENIJE

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tel: + 386 (0)1 200 78 00 / fax: + 386 (0)1 257 35 89

Date: 11. 5. 2009

H A R M O N I Z E D   S A M P L E R

Dear colleagues,

The last of May is approaching and I hope you all have their funnels and containers prepared.
According to responses for the bird rings and sieves I got view answers and I chose GB model since their bird ring satisfactory fulfills its task and do as low air barrier as possible.

THE BIRD RING

Accessories:
- 9x waste water tube, diameter 160 mm, 5 m length (Figure 1) (most economic solution; it's possible to buy shorter ones but then you'll need more of them!),
- 11x galvanized threaded rods (length 100 cm, M4-metric coil of rod, diameter ≈ 4 mm),
- 132x thrust washers (M4),
- 264x female screws (all three on figure 2) and
- 70 m of fishing line, thickness 0,33 mm.

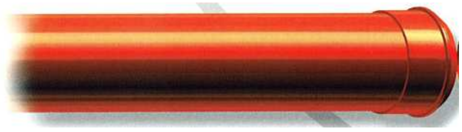


Figure 1: Example of waste water pipe.

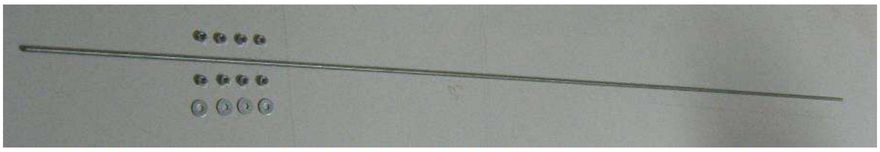


Figure 2: galvanized threaded rod, 4 thrust washers and 8 female screws.

Procedure:

First cut waste water tube to proper length (approx. 1,3 m, figure 3a) and drill 8 holes (diameter 10 mm) 18 cm and 8 holes (diameter 10 mm) 60 cm below the top of the tube (Figure 3b) for air conditioning:

Figure 3a, b: cut waste water tube (approx. height 1,3 m)

Drill 4 holes of 4 mm diameter 3 cm below the top of the tube (Figure 5). With the help of model (Figure 4) it's much easier.

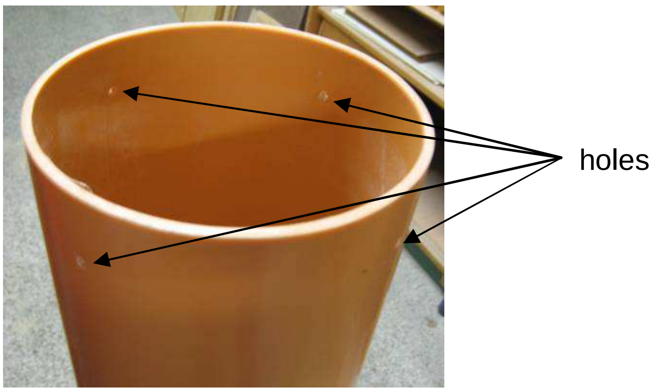


Figure 4: Model for drilling holes Figure 5: Positions of the holes.
Cut galvanized threaded M4 rods to 31 cm length (Figure 6).

Figure 6: threaded rods, 31 cm

Fix the rod in the vice at 5,5 cm length (Figure 7):

Figure 7.

Gentle fold it to get 90°angle (Figures 8, 9 and 10):

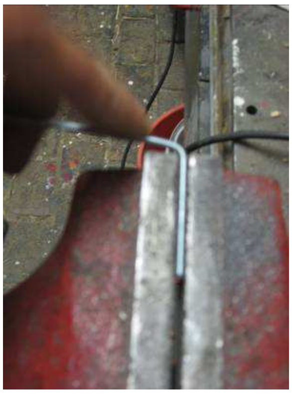


Figure 8.

Figure 9.

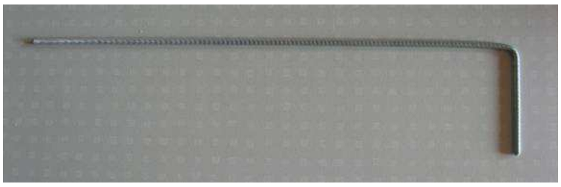


Figure 10.

Screw on shorter part of the folded rod one female screw, ad thrust washer and put it through the hole in the waste water tube from the outer side. From the inner side screw another female screw just for the thickness of it. Center the longer part of the rod vertically upwards and tight outside female screw firmly. Repeat the procedure four times per waste water tube.

After the rods are firmly fixed, strain fishing line on 9 and 4,5 cm above the funnel plane. The bird ring is made (Figure 11).

Figure 11: The end look of the bird ring with the funnel in place.

THE SIEVE

The sieve will look like this (Figure 12) and we'll made them for all the participants and send them by mail to contact addresses.

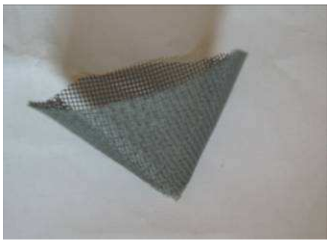


Figure 12: sieve (mesh) of 1 mm holes, outside the funnel.

Figure 13: Sieve, placed in the funnel.

If any questions or troubles please don't hesitate to contact me!

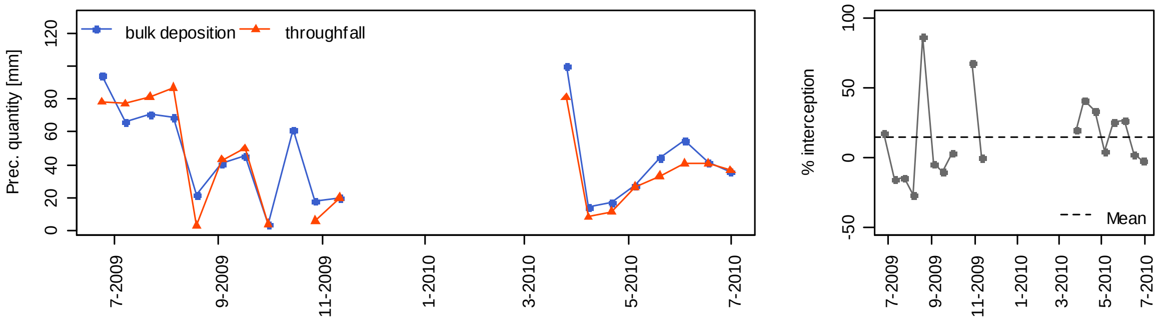
Best regards,

Daniel Žlindra

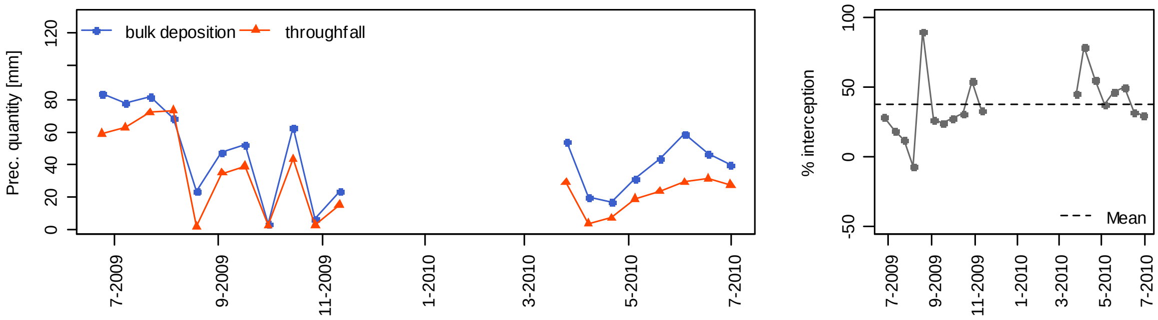
Annex 8: Time courses of the collected amounts of precipitation with different collectors

02

Harmonized collector



National collector



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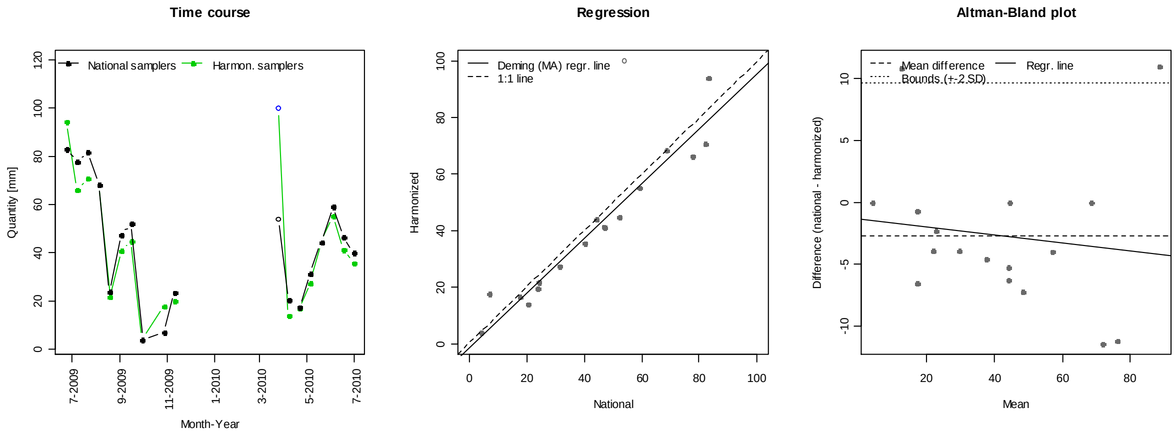
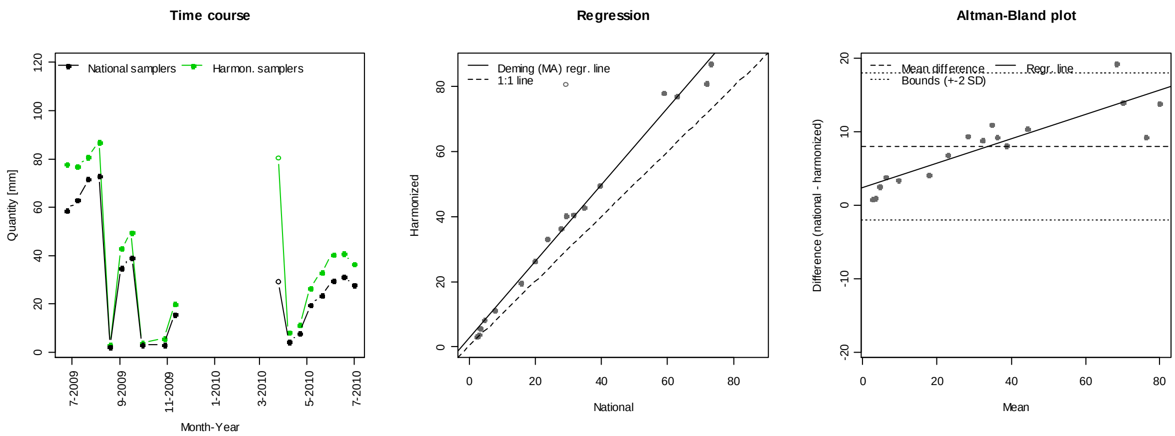


THROUGHFALL



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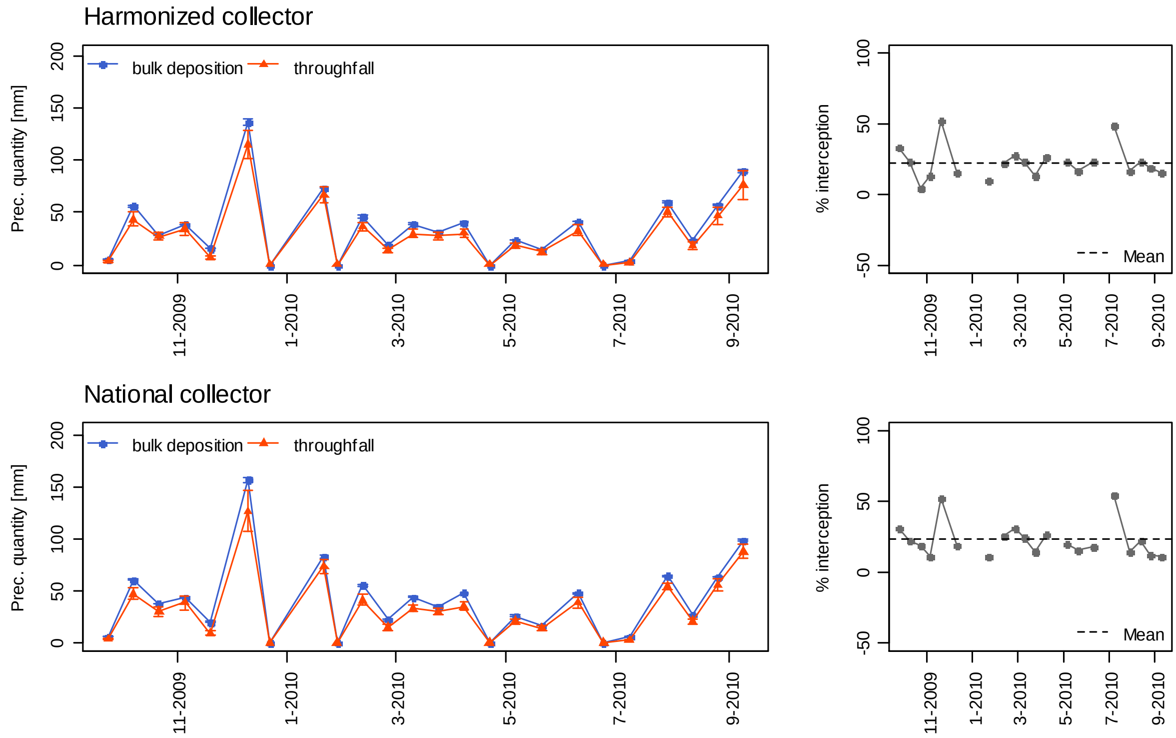

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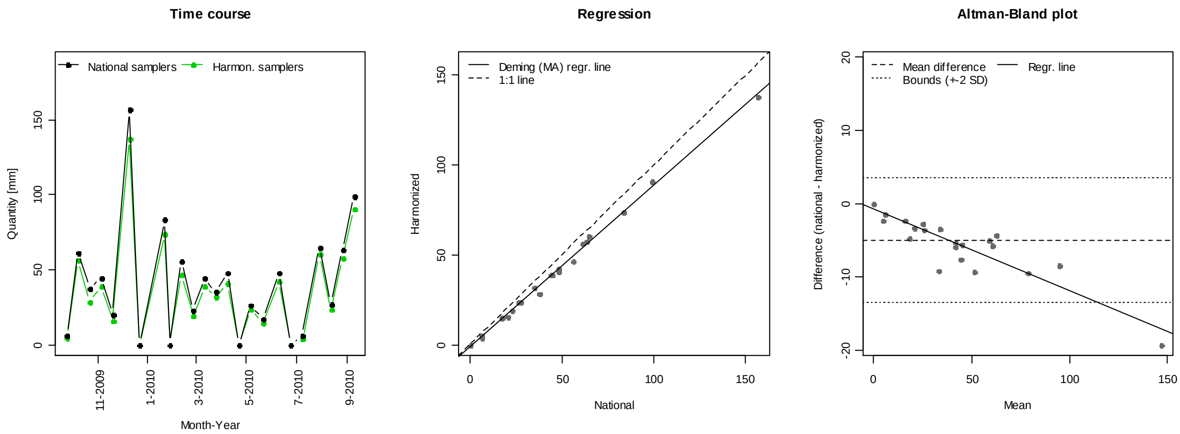

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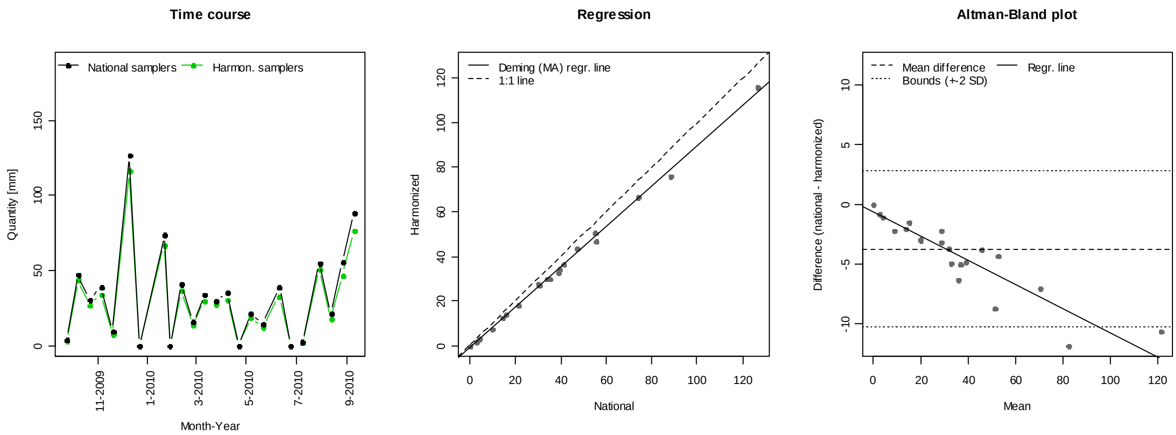

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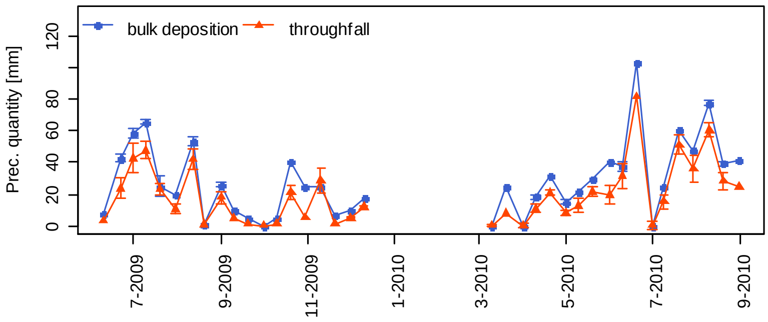
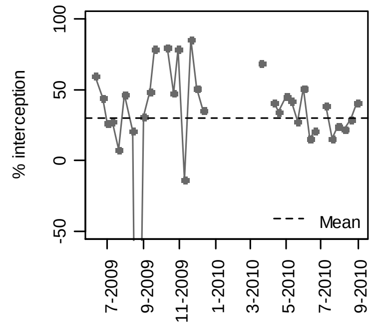
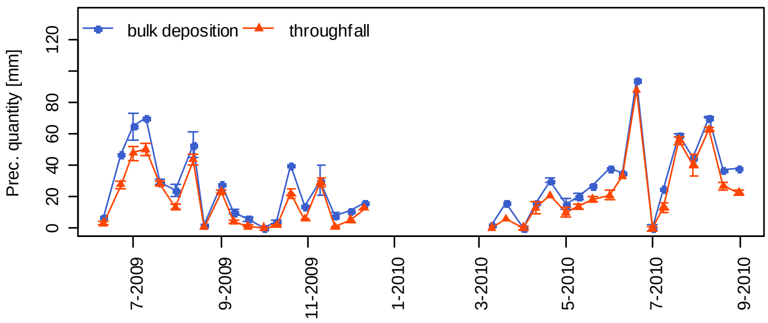
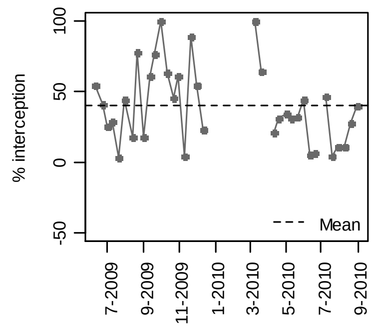
Harmonized collector





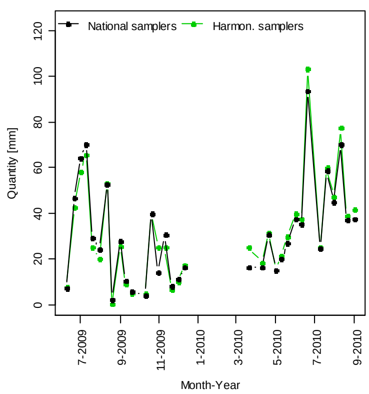
National collector





BULK

Time course



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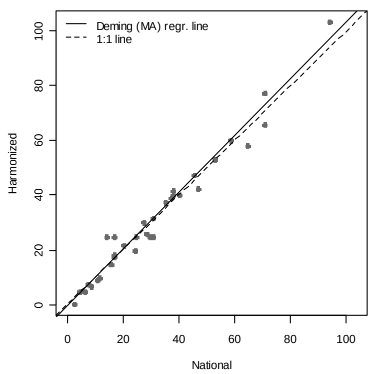
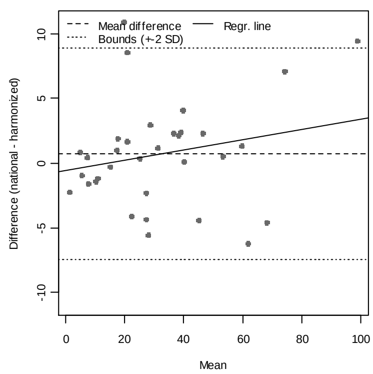
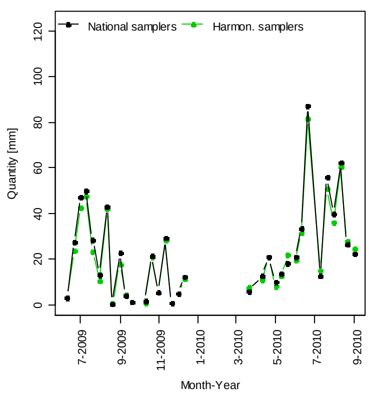


Altman-Bland plot



THROUGHFALL

Time course



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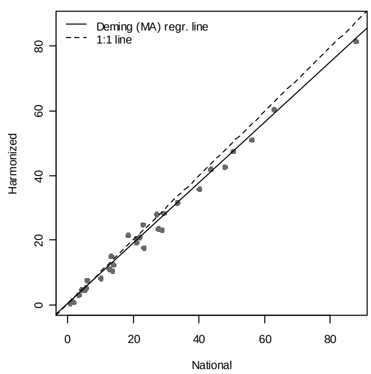
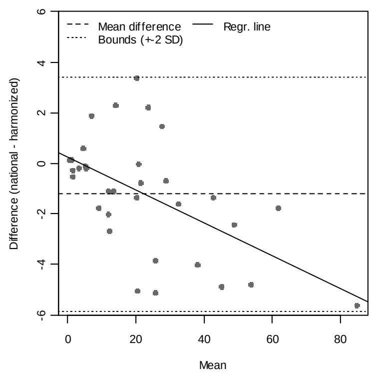


Altman-Bland plot



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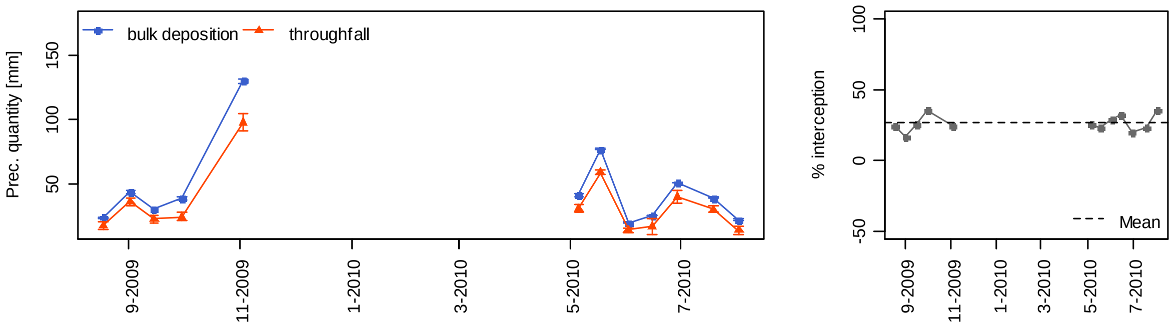
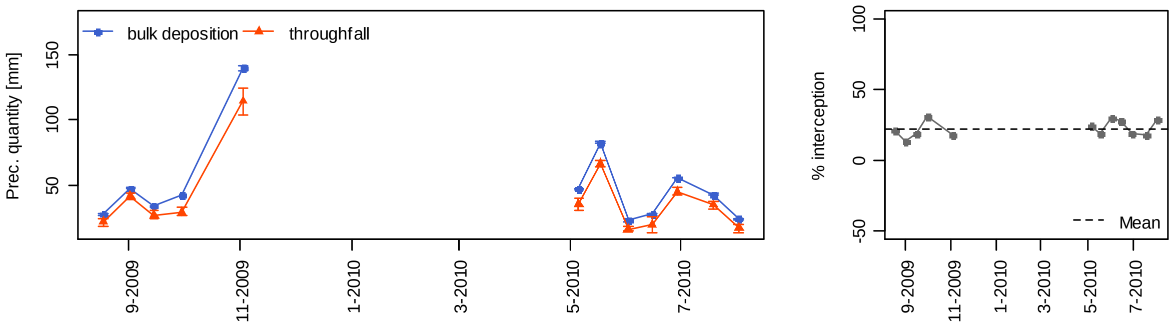
Harmonized collector



National collector



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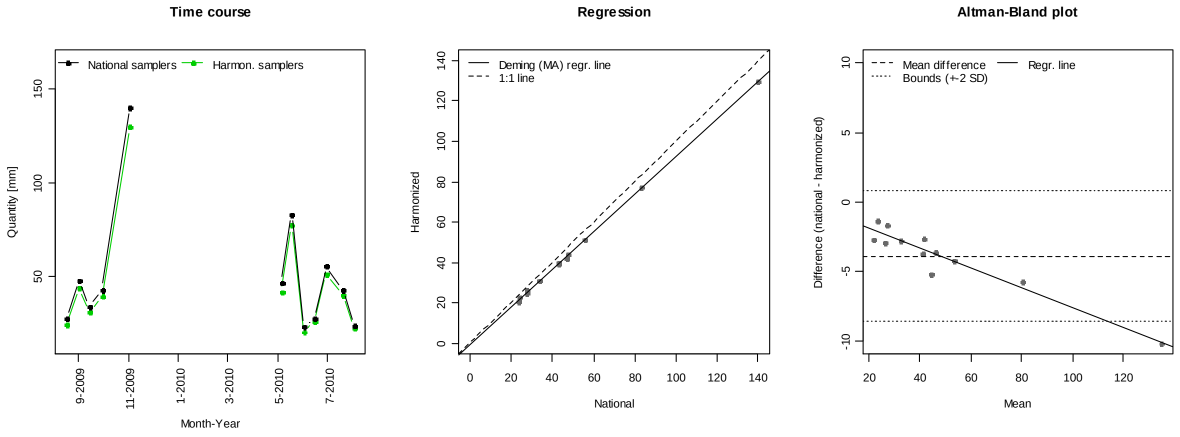

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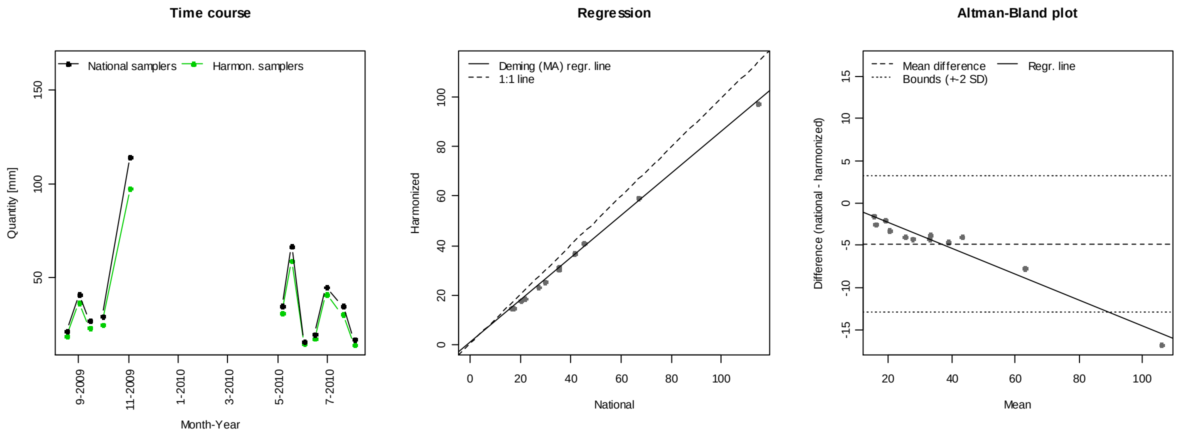

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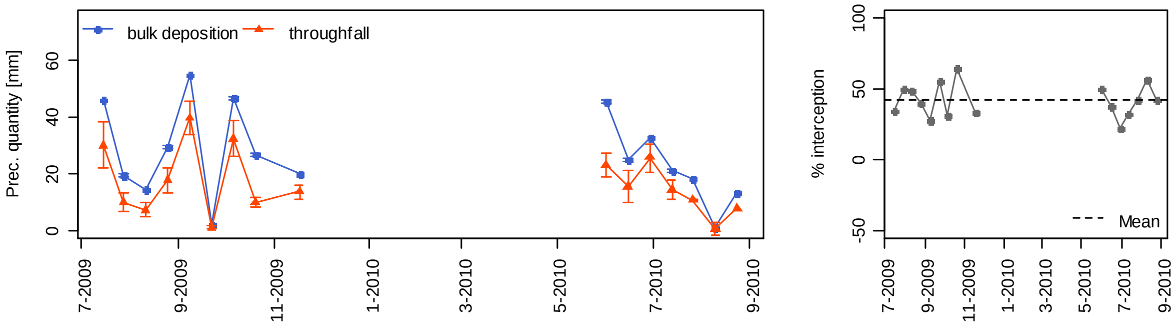
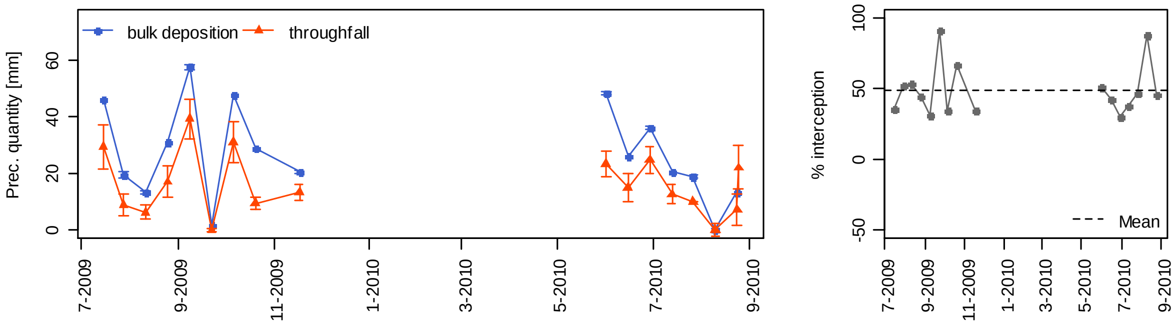
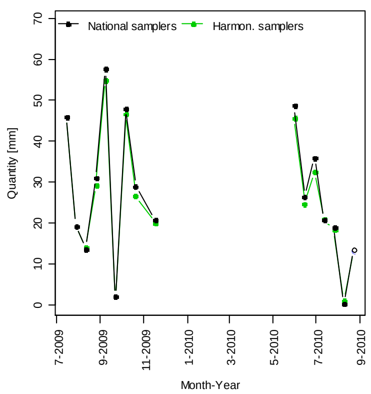


National collector

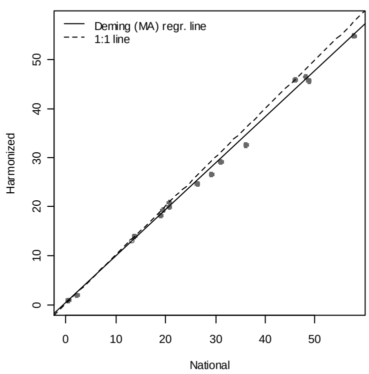


BULK

Time course



Regression



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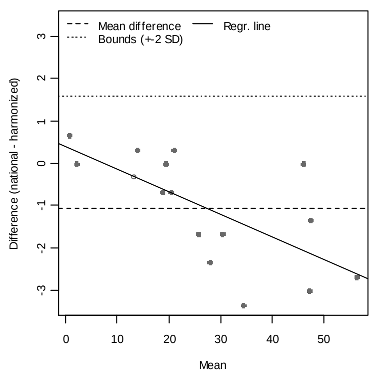
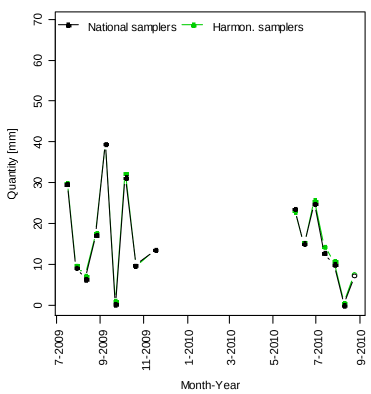


THROUGHFALL

Time course



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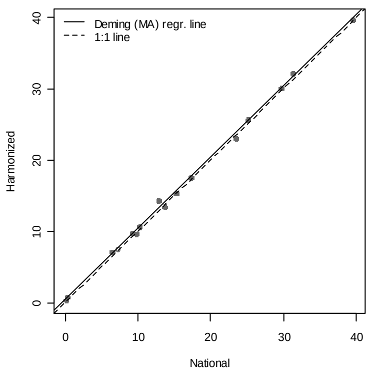
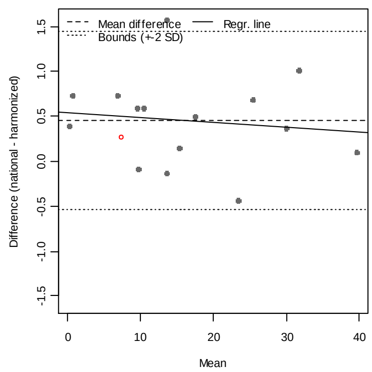


Altman-Bland plot



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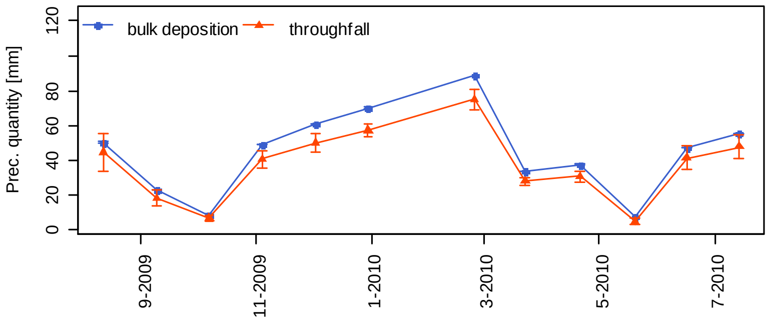
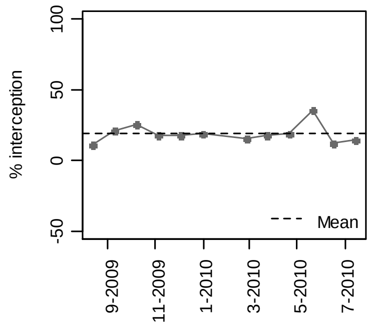
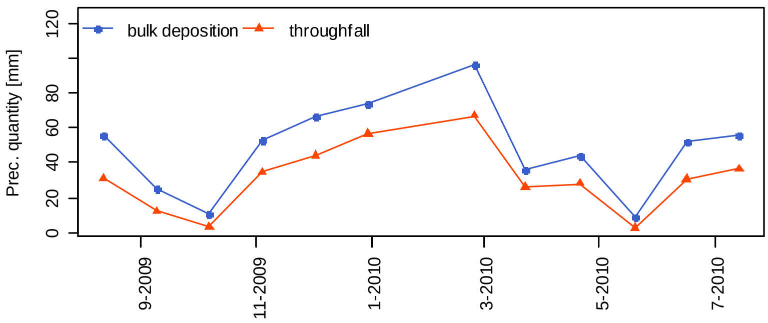
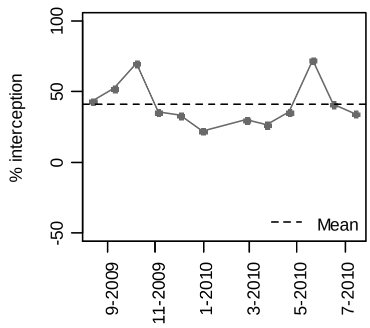
Harmonized collector





National collector





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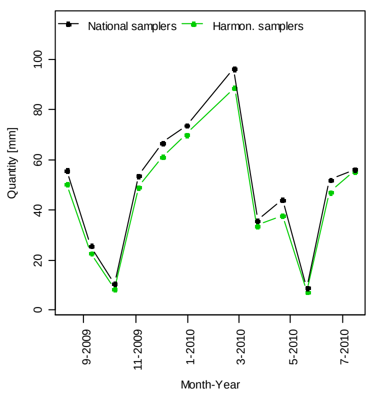
Time course



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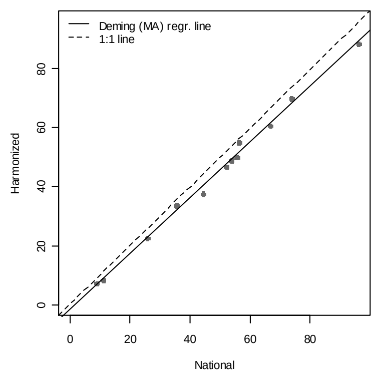

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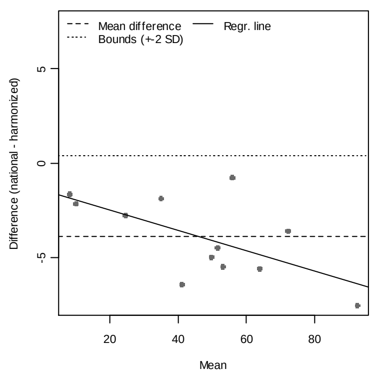
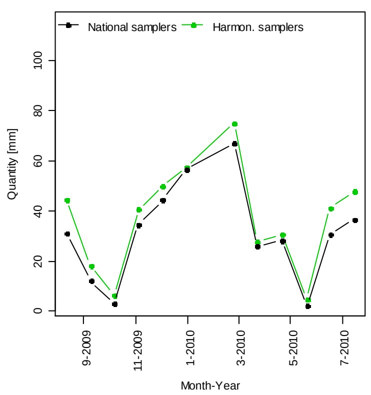
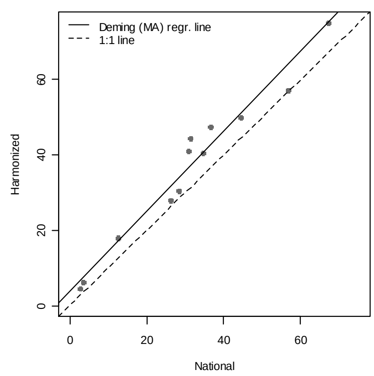


THROUGHFALL

Time course



Regression



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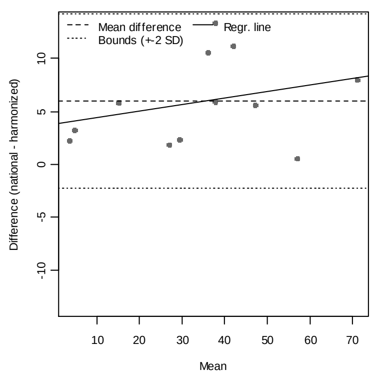

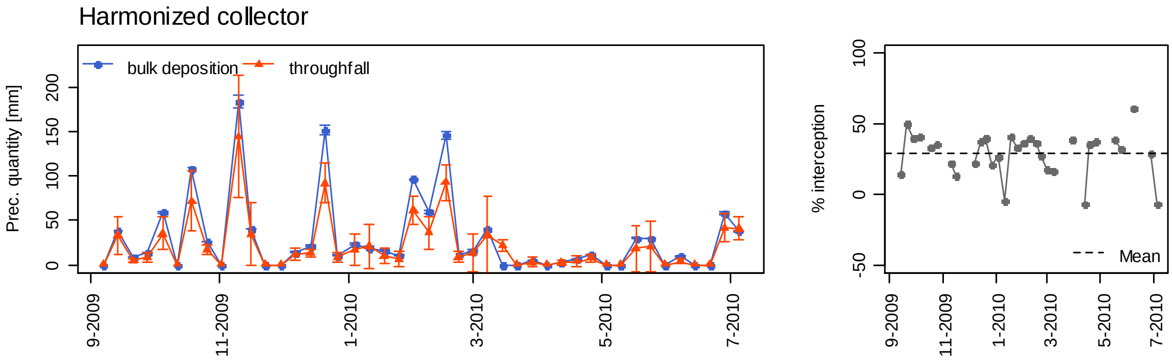

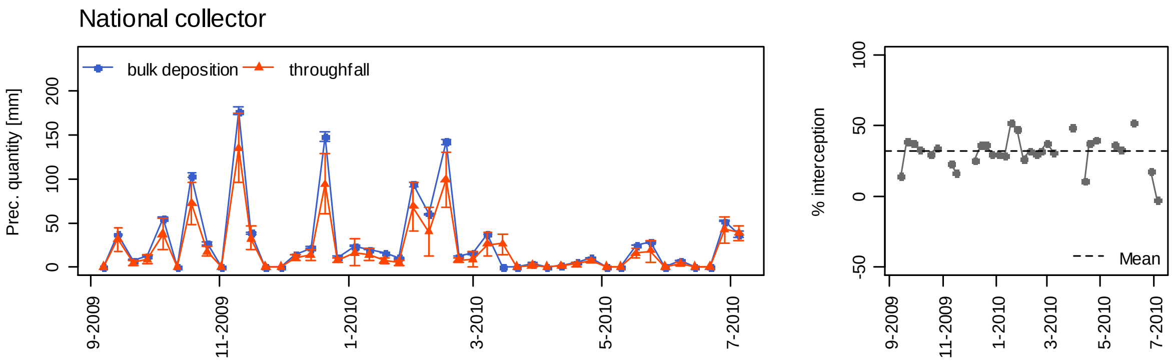

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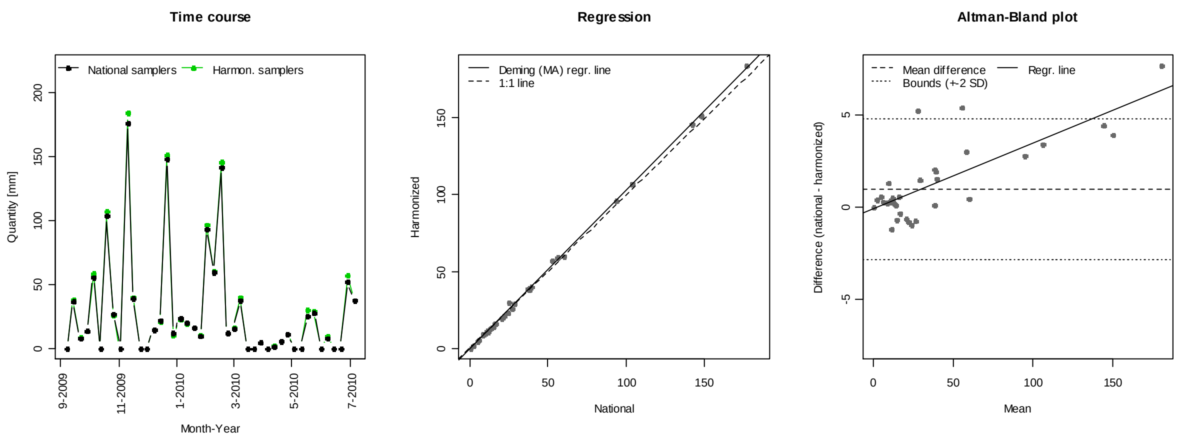

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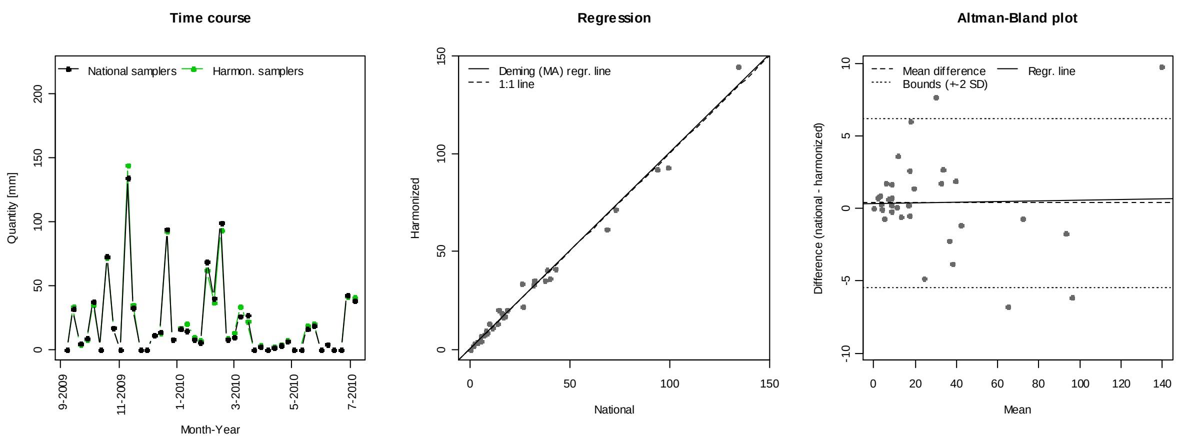

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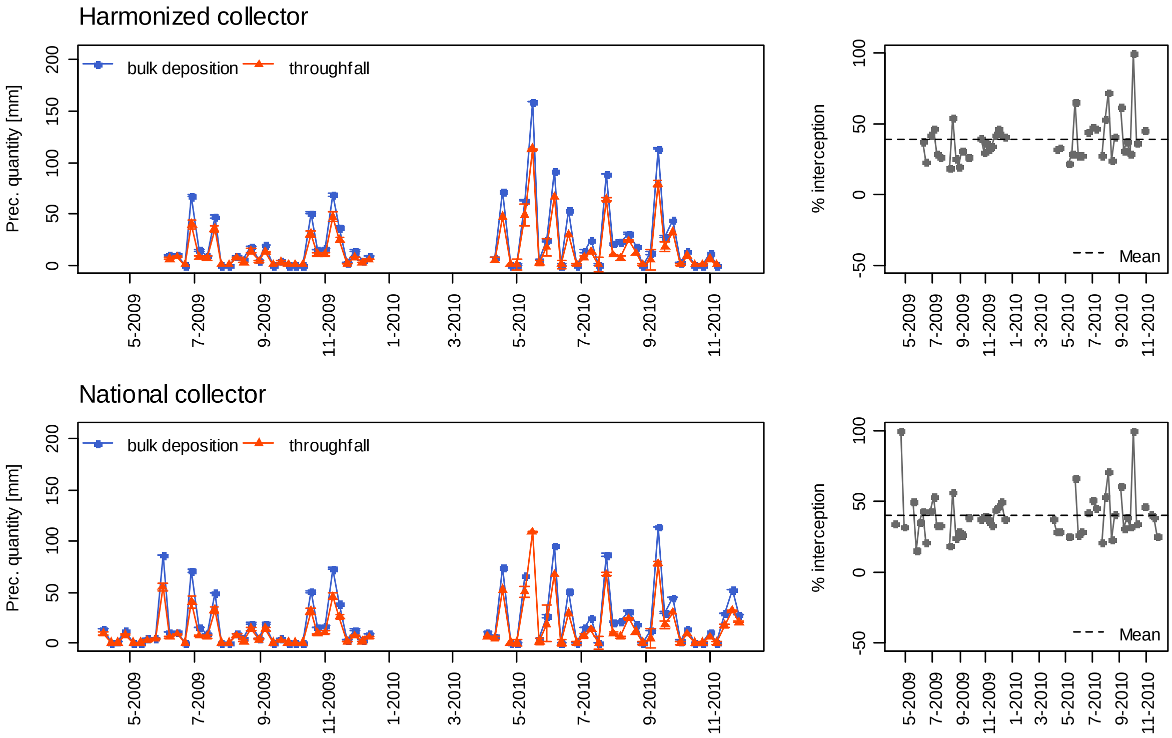

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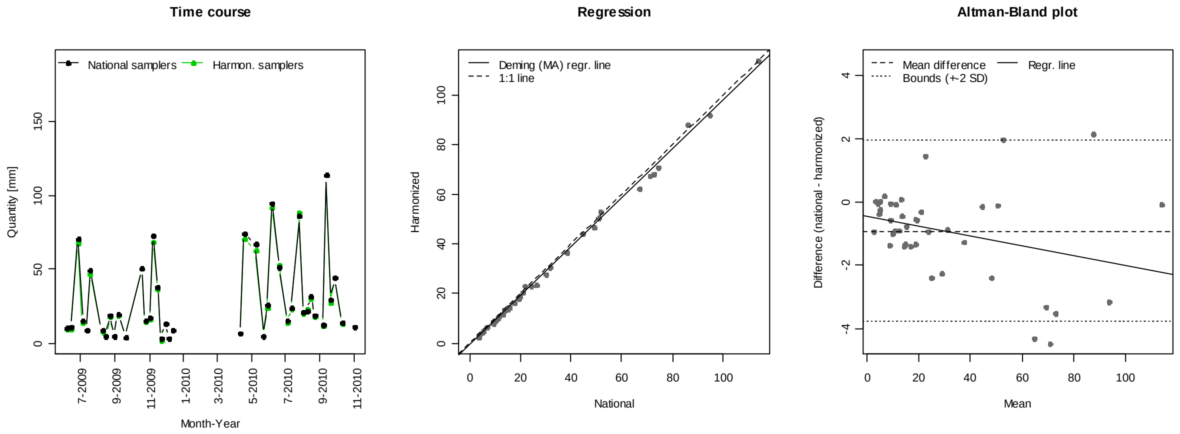

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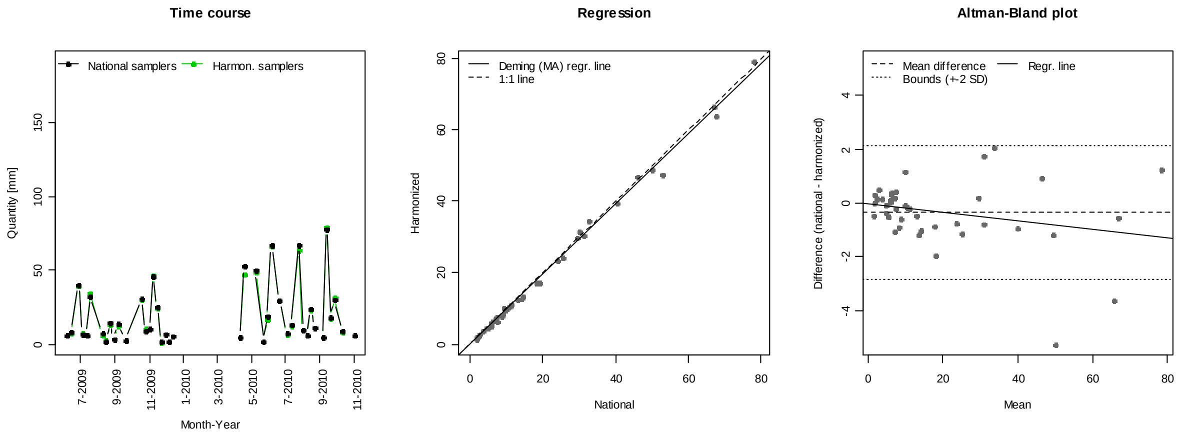

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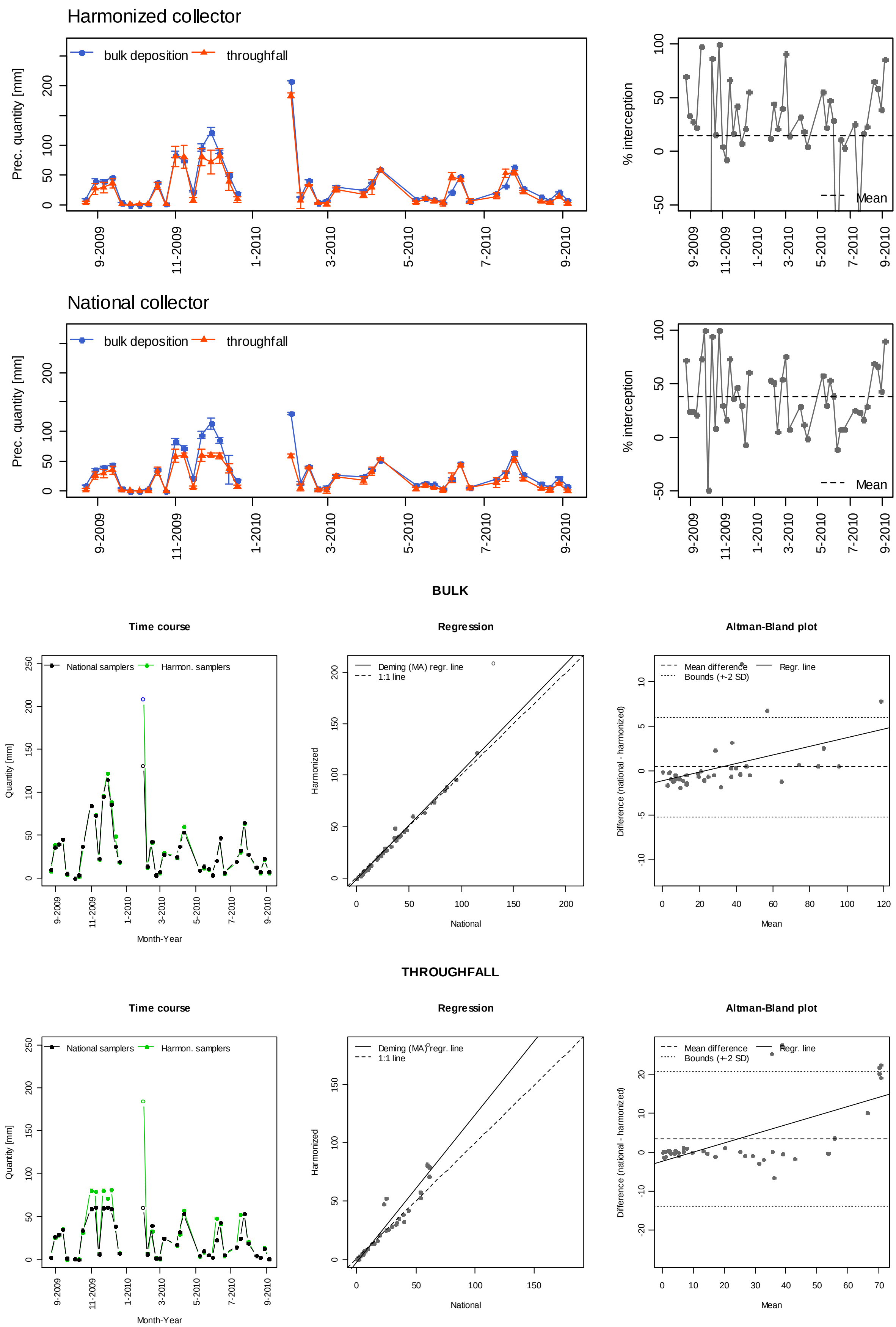
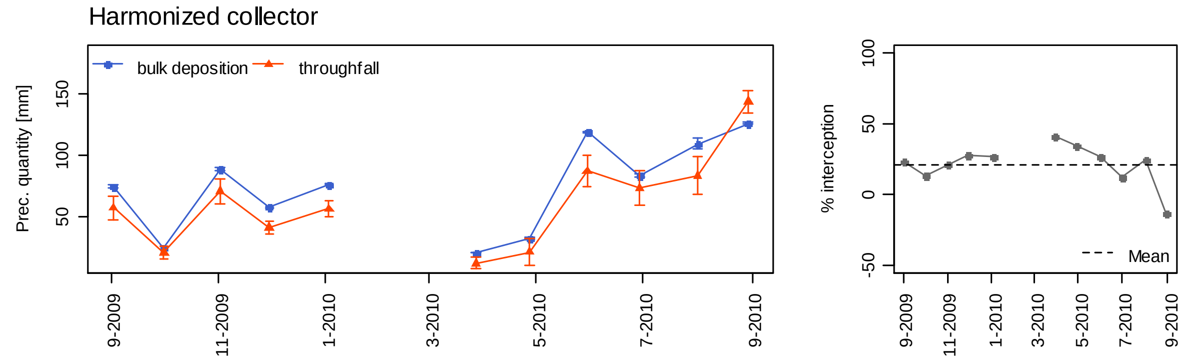
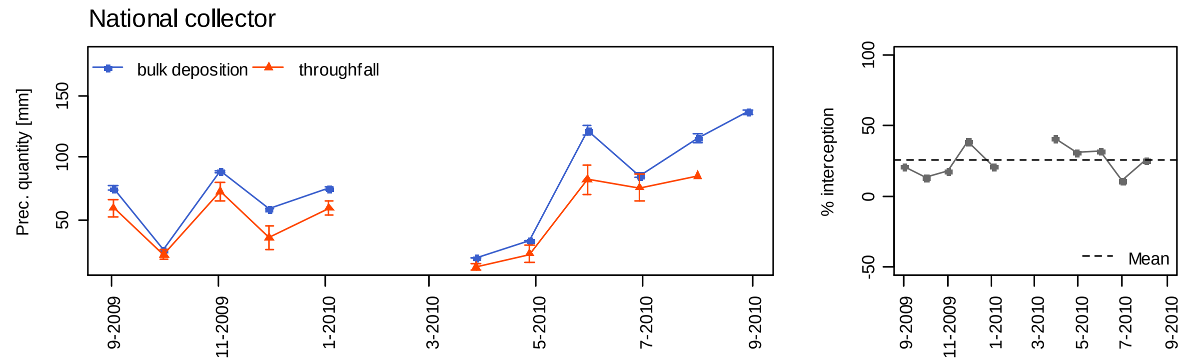


Harmonized collector
bulk deposition
throughfall
Prec. quantity [mm]
% interception
Mean
9-2009
11-2009
1-2010
3-2010
5-2010
7-2010
9-2010
National collector
bulk deposition
throughfall
Prec. quantity [mm]
% interception
Mean
BULK
Time course
National samplers
Harmon. samplers
Quantity [mm]
Month-Year
Regression
Deming (MA) regr. line
1:1 line
Harmonized
National
Altman-Bland plot
Mean difference
Bounds (+-2 SD)
Regr. line
Difference (national - harmonized)
Mean
THROUGHFALL
Time course
National samplers
Harmon. samplers
Quantity [mm]
Month-Year
Regression
Deming (MA) regr. line
1:1 line
Harmonized
National
Altman-Bland plot
Mean difference
Bounds (+-2 SD)
Regr. line
Difference (national - harmonized)
Mean

18





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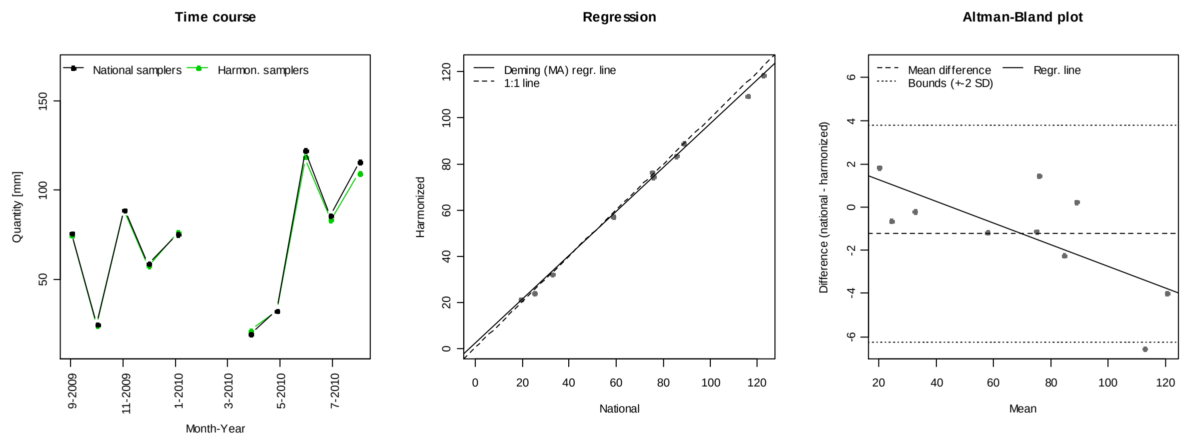

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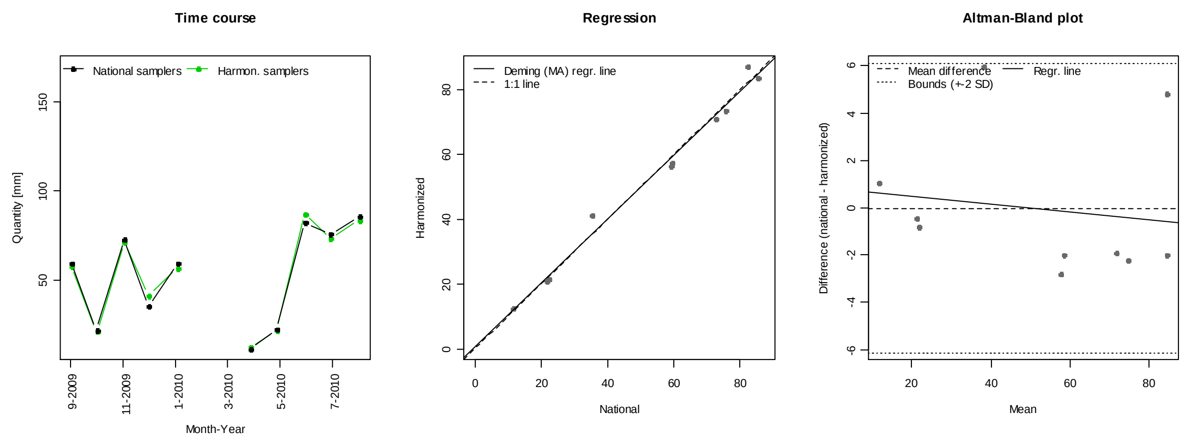

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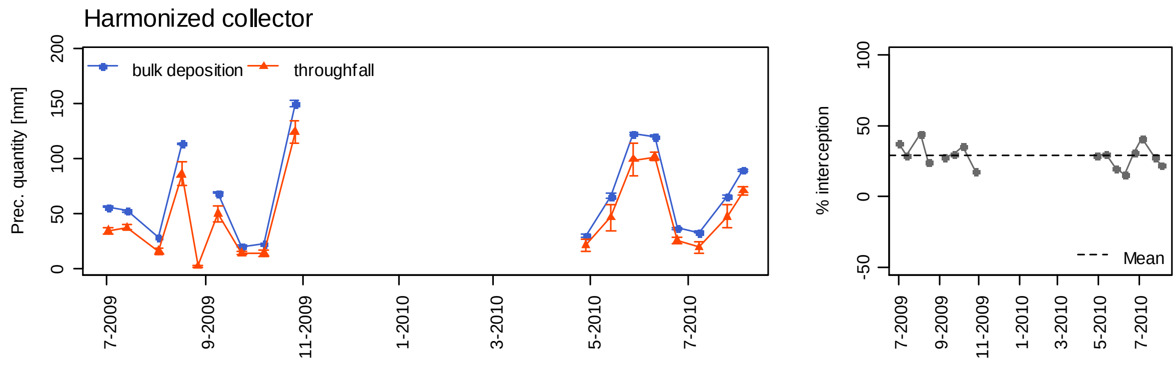

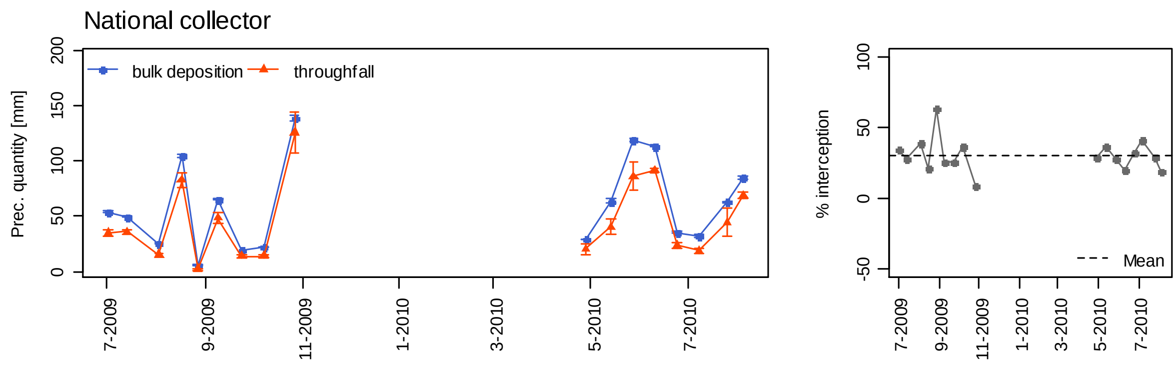

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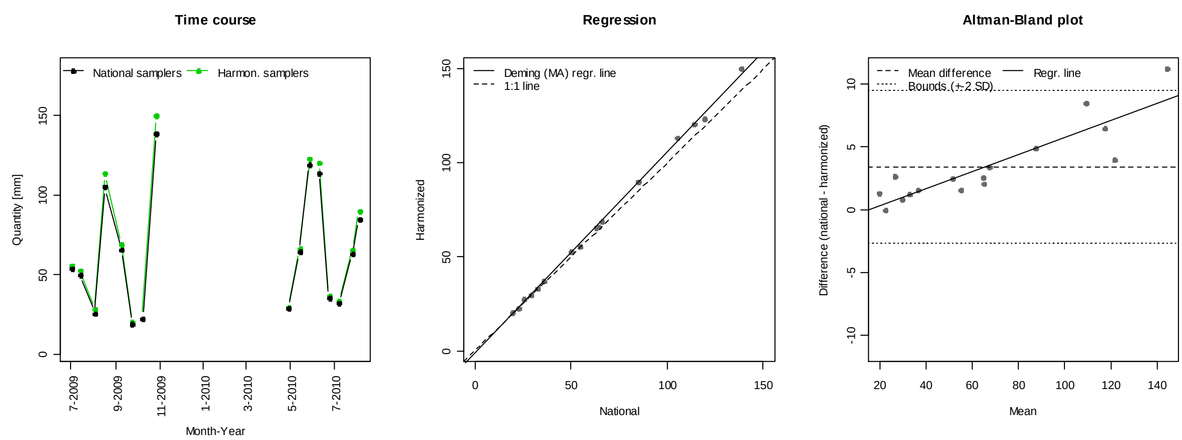

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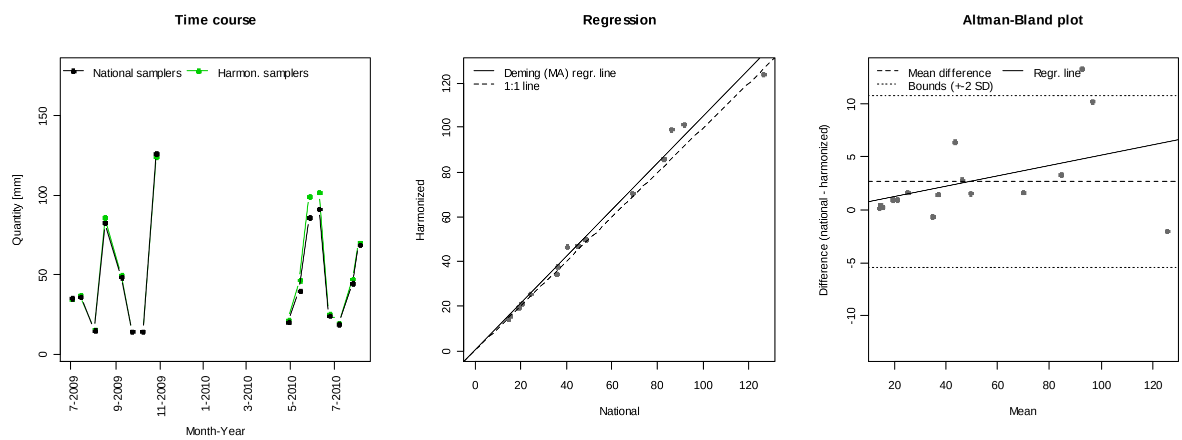
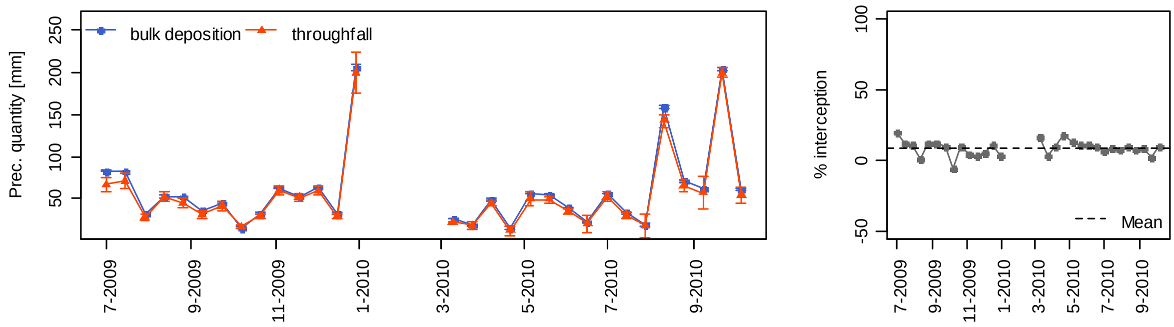
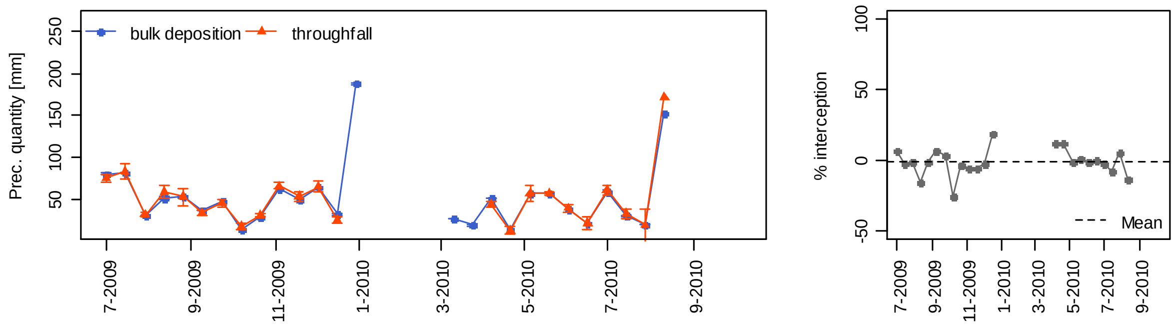


22

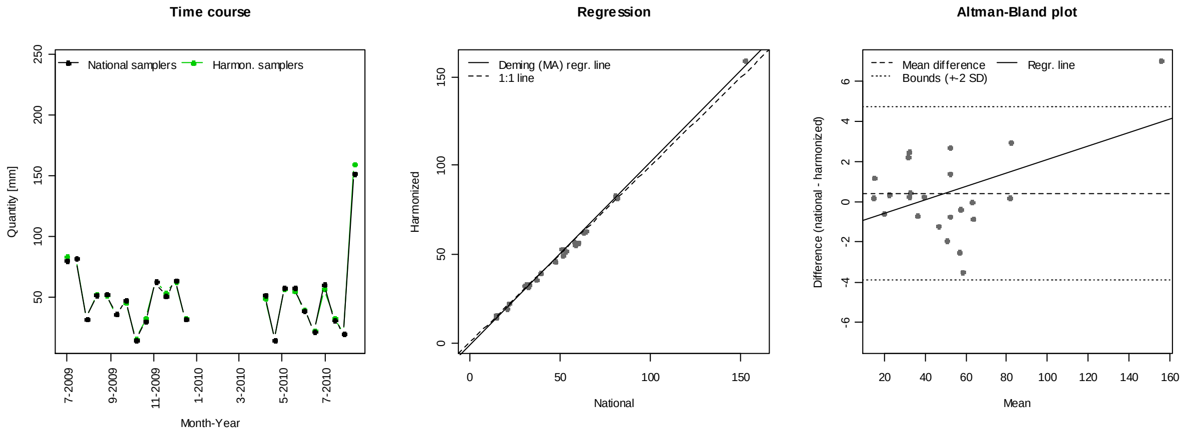
Harmonized collector



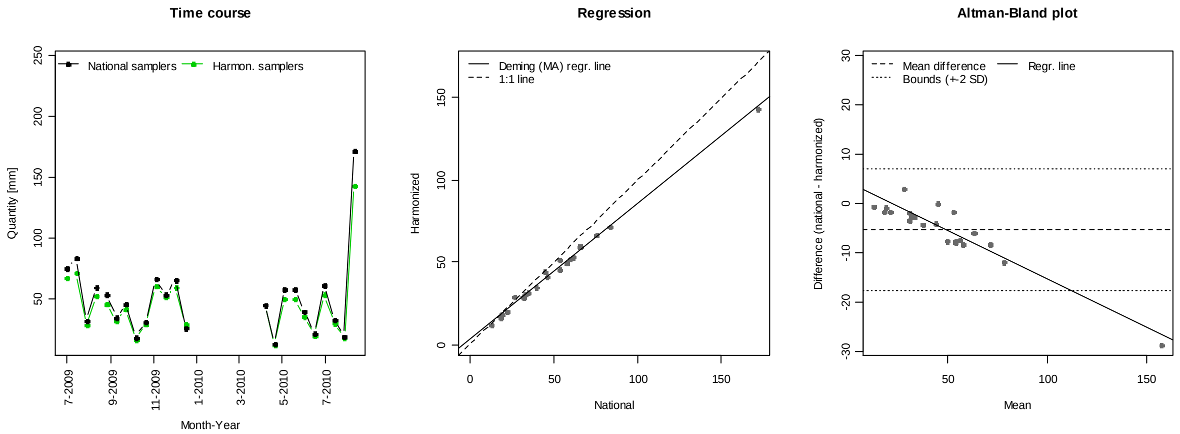
National collector



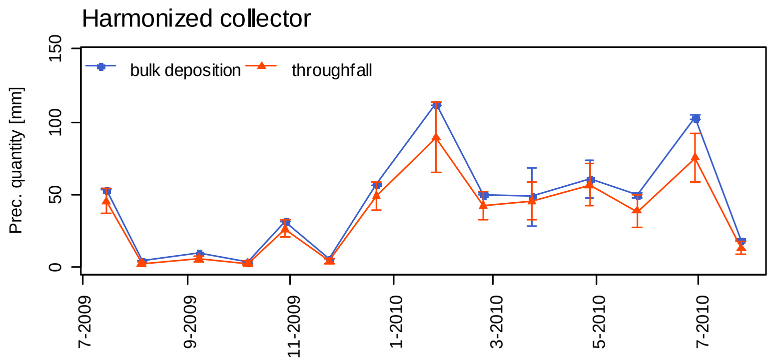
BULK

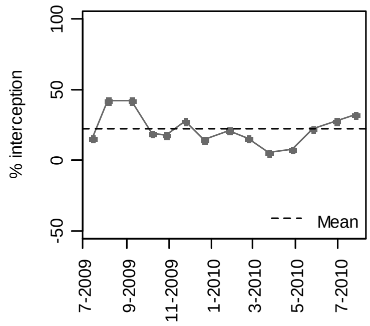


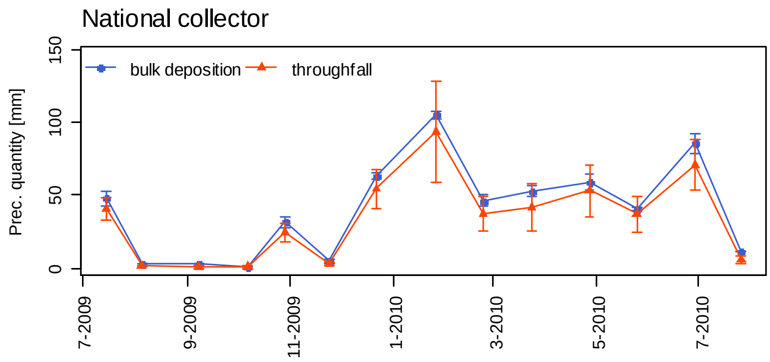
THROUGHFALL

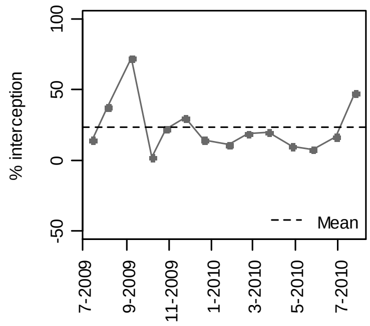


23

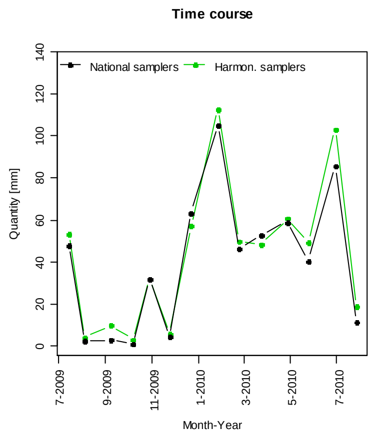


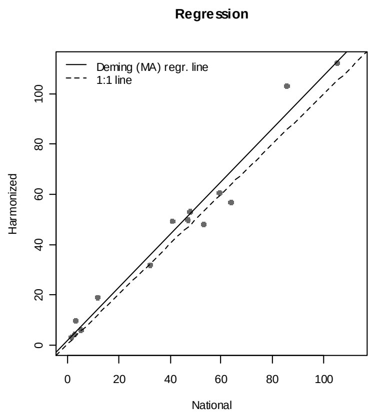


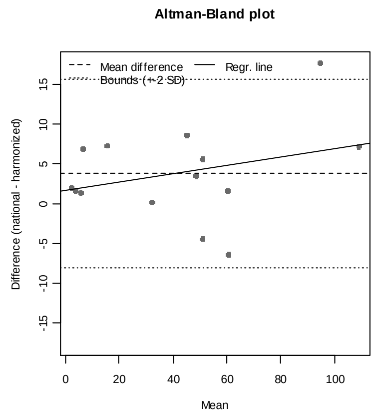




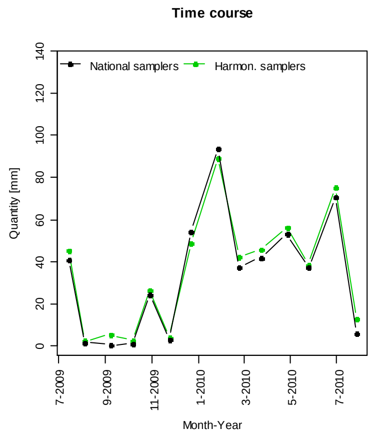
BULK

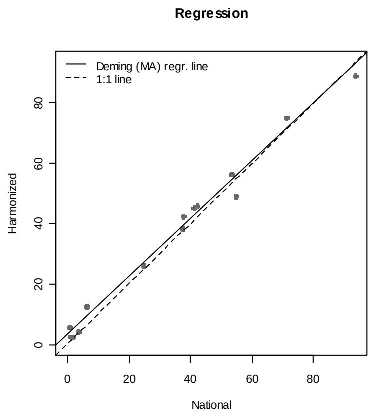


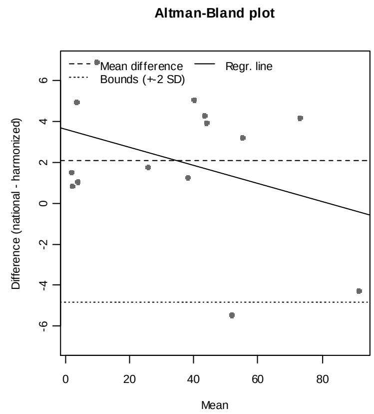




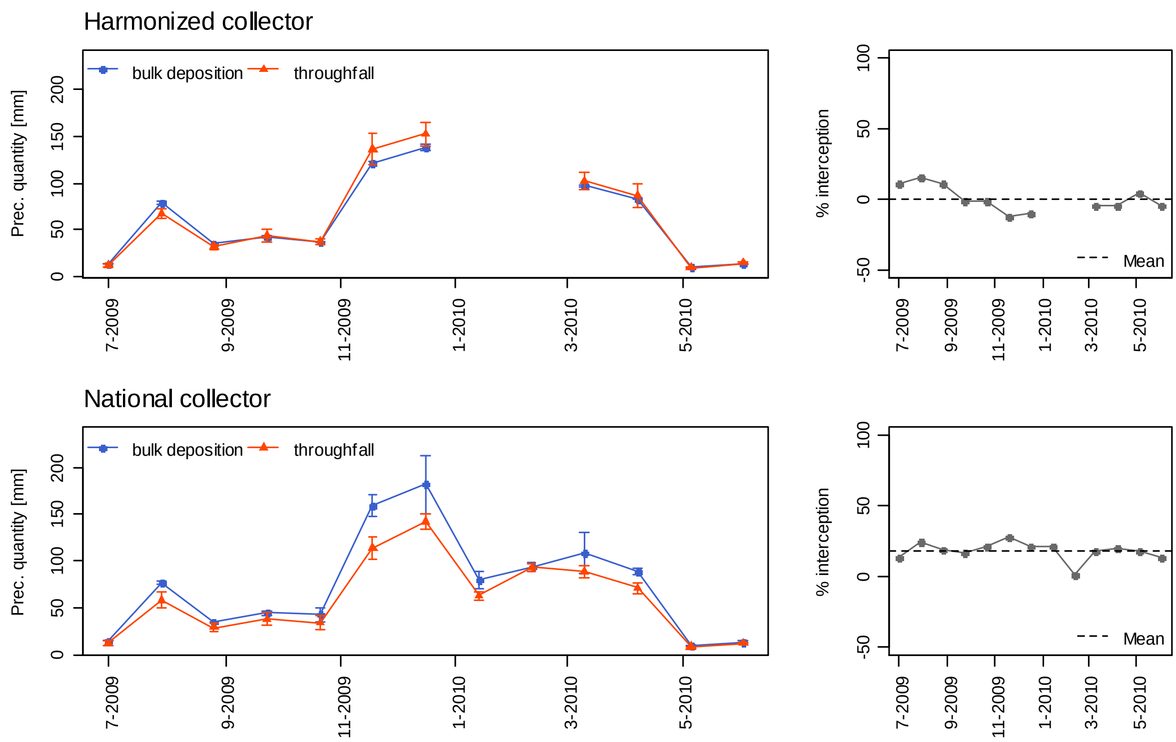
THROUGHFALL



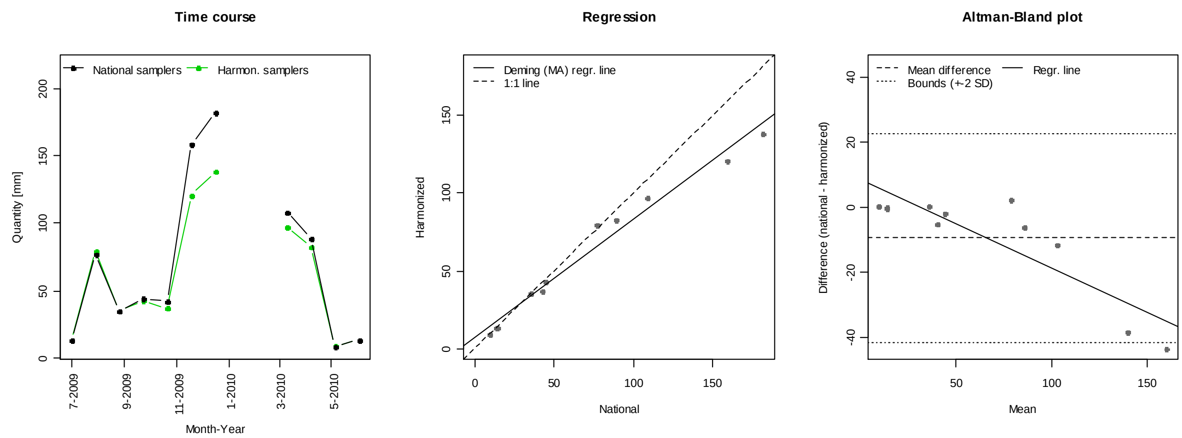




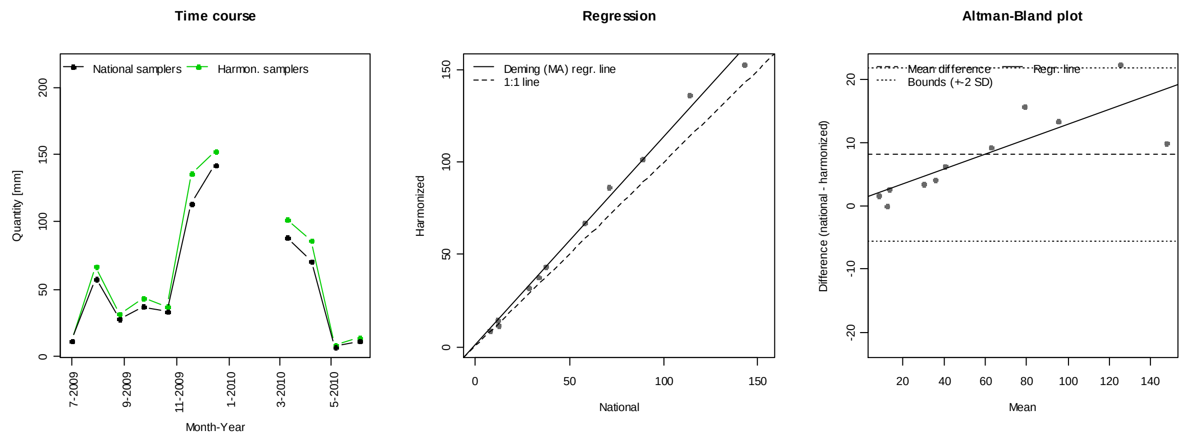
26



BULK

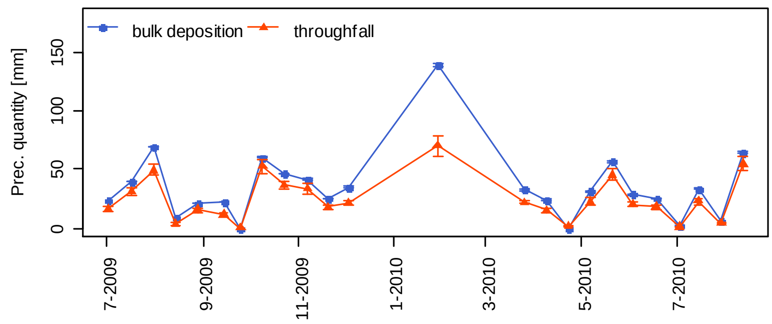


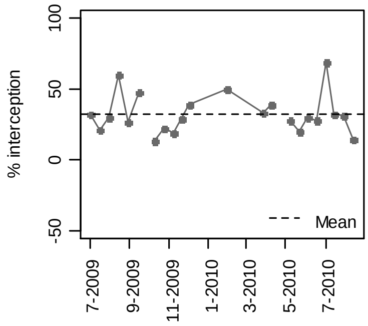
THROUGHFALL



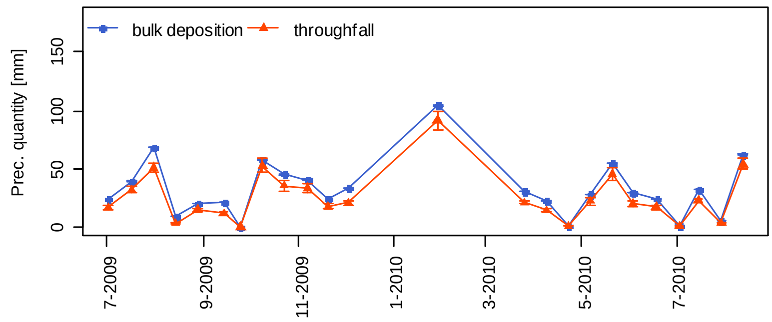
30

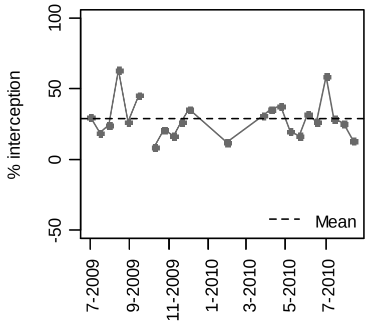
Harmonized collector





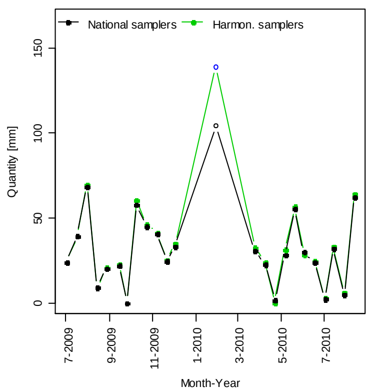
National collector



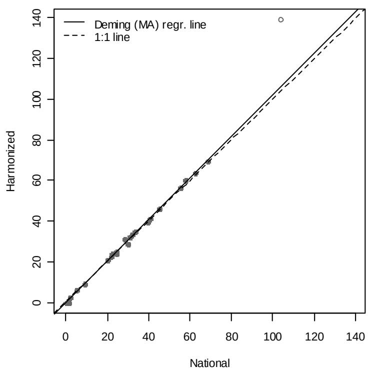


BULK

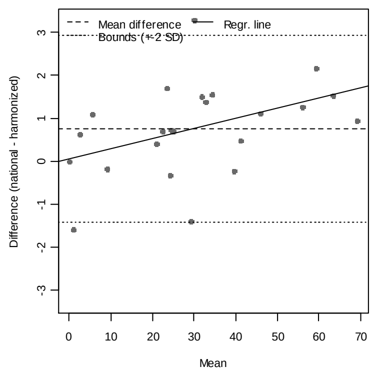
Time course



Regression

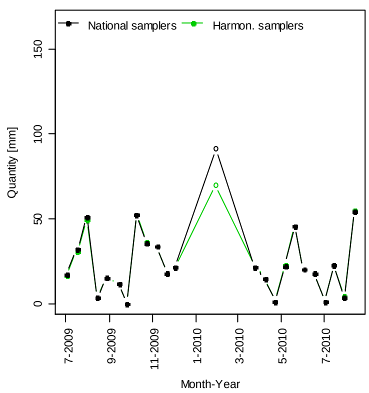


Altman-Bland plot

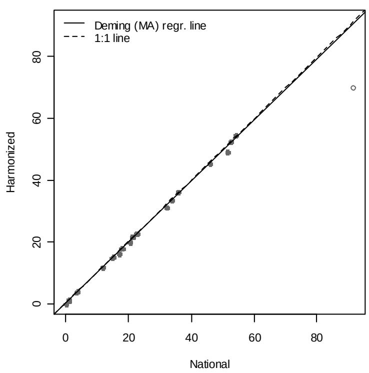


THROUGHFALL

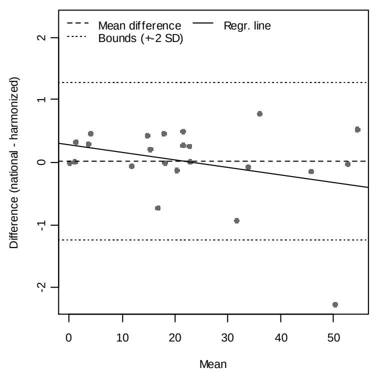
Time course



Regression

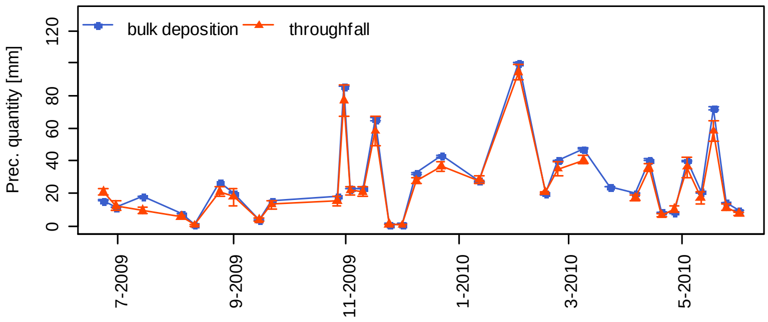


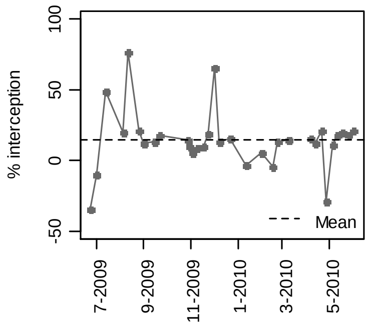
Altman-Bland plot



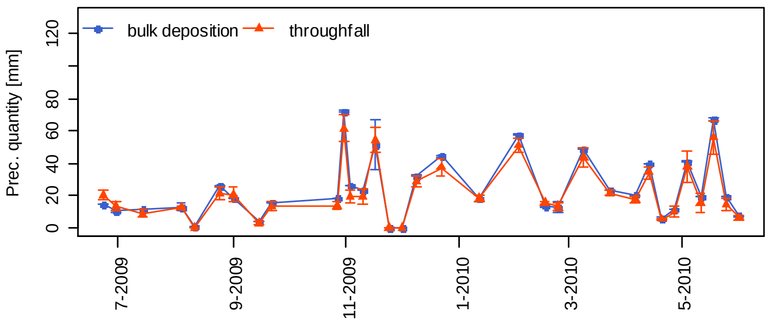
40

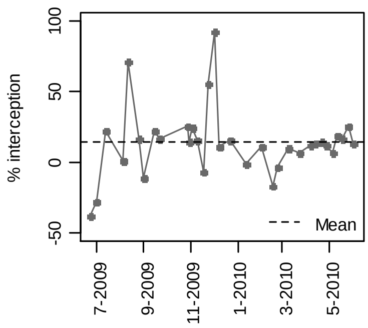
Harmonized collector



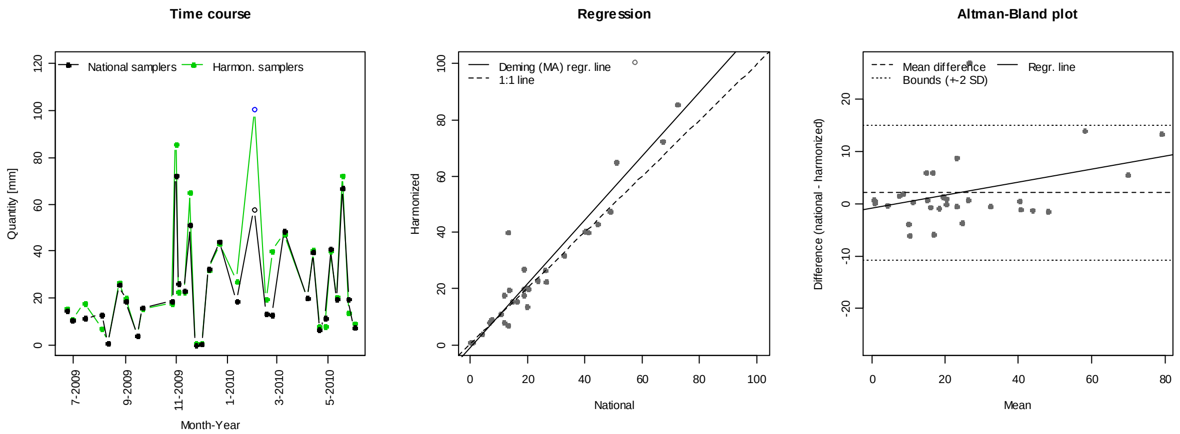


National collector





BULK



THROUGHFALL

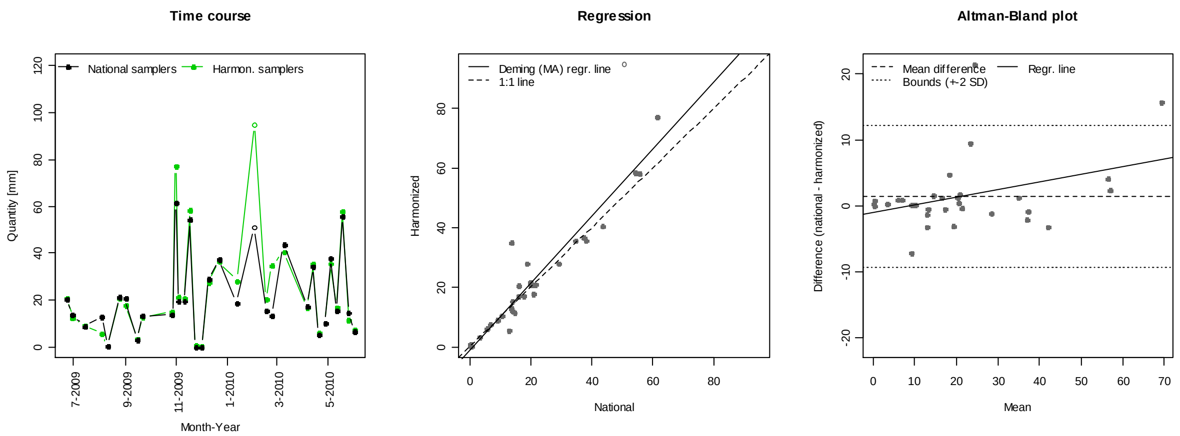


Table: Statistics on bias between national and harmonized collectors for throughfall quantities. For statistical tests a significance level (α) of 0.05 was used.

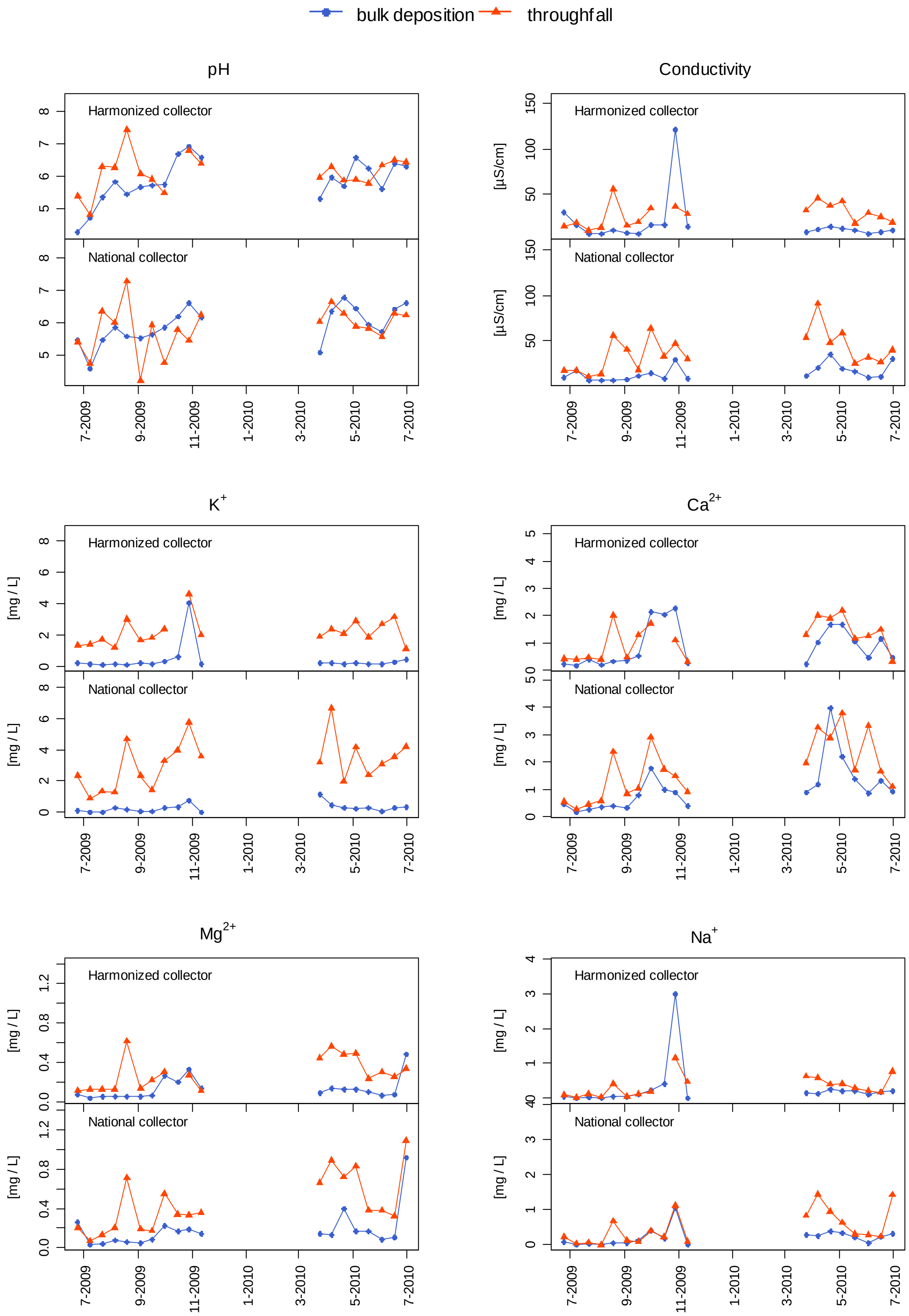
Associated beneficiary	Mean difference (mm)	SD	Signif.	Intercept Deming regr.	Inercept signif.	Slope Deming regr.	Slope signif.	R^2	No. of data points
02	7.6	10.2	sig.	2.22	sig.	1.19	sig.	0.991	18
03	-3.7	6.5	sig.	-0.59	sig.	0.90	sig.	0.998	24
07	-1.2	4.6	sig.	0.23	ns	0.94	sig.	0.991	33
09	-4.9	8.1	sig.	0.67	ns	0.86	sig.	0.999	12
10	0.5	1.0	sig.	0.54	sig.	0.99	ns	0.998	15
11	5.5	10.3	sig.	2.65	ns	1.10	ns	0.906	13
12	0.3	5.8	ns	0.29	ns	1.00	ns	0.991	44
13	-0.3	1.4	Ns	-0.04	ns	0.98	ns	0.996	41
14	3.5	17.3	sig.	-2.59	ns	1.27	sig.	0.919	39
18	0.0	6.1	ns	0.83	ns	0.98	ns	0.988	10
21	2.7	8.1	sig.	0.29	ns	1.05	ns	0.989	16
22	-5.3	12.3	sig.	3.63	sig.	0.82	sig.	0.995	23
23	2.1	6.9	sig.	3.54	sig.	0.96	ns	0.987	14
26	8.1	13.7	sig.	1.19	ns	1.13	sig.	0.993	11
30	0.0	1.3	ns	0.28	ns	0.99	ns	0.999	23
40	1.5	10.8	ns	-1.08	ns	1.12	sig.	0.917	31

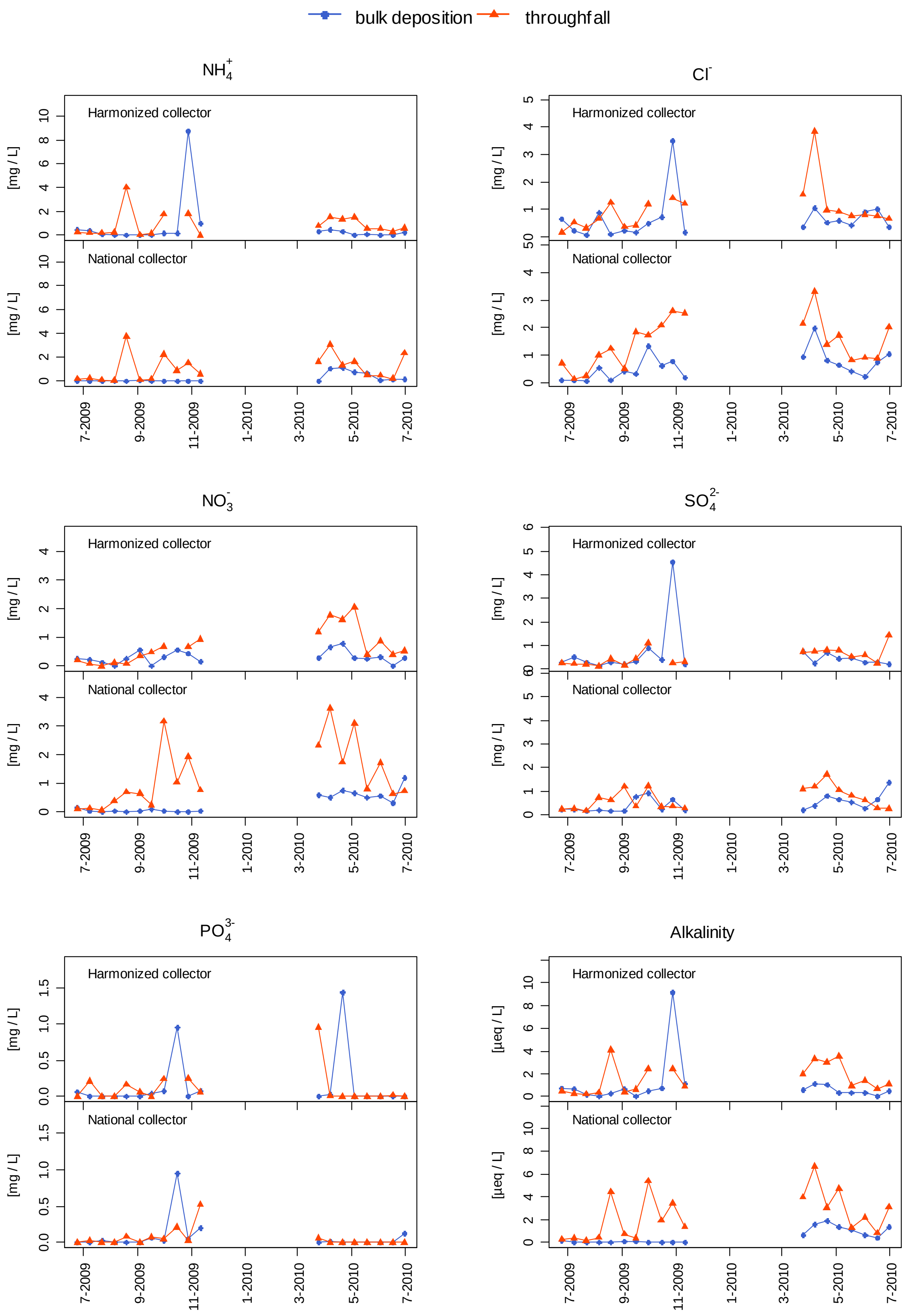
Table: Statistics on bias between national and harmonized collectors for bulk quantities. For statistical tests a significance level (α) of 0.05 was used.

Associated beneficiary	Mean difference (mm)	SD	Signif.	Intercept Deming regr.	Inercept signif.	Slope Deming regr.	Slope signif.	R^2	No. of data points
02	-2.8	12.0	ns	-1.78	ns	0.97	ns	0.943	18
03	-4.9	8.5	sig.	-0.71	ns	0.90	sig.	0.997	24
07	0.7	8.2	ns	-0.55	ns	1.04	ns	0.969	33
09	-3.9	4.7	sig.	-0.50	ns	0.93	sig.	1.000	12
10	-1.1	2.6	sig.	0.38	ns	0.95	sig.	0.996	15
11	-3.6	12.3	ns	-4.14	ns	1.01	ns	0.906	13
12	1.0	3.8	sig.	-0.07	ns	1.04	sig.	0.999	44
13	-0.9	1.9	ns	-0.46	ns	0.98	ns	0.998	41
14	0.4	5.6	ns	-1.16	sig.	1.05	sig.	0.993	39
18	-1.2	5.0	ns	2.19	ns	0.95	sig.	0.997	10
21	3.4	6.0	sig.	-1.06	ns	1.07	sig.	0.999	16
22	0.4	4.3	ns	-1.29	ns	1.03	sig.	0.996	23
23	3.8	11.8	sig.	1.70	ns	1.05	ns	0.972	14
26	-9.4	32.1	ns	7.40	sig.	0.76	sig.	0.977	11
30	0.8	2.2	sig.	0.07	ns	1.02	sig.	0.997	23
40	2.1	12.9	ns	-1.03	ns	1.14	sig.	0.909	31

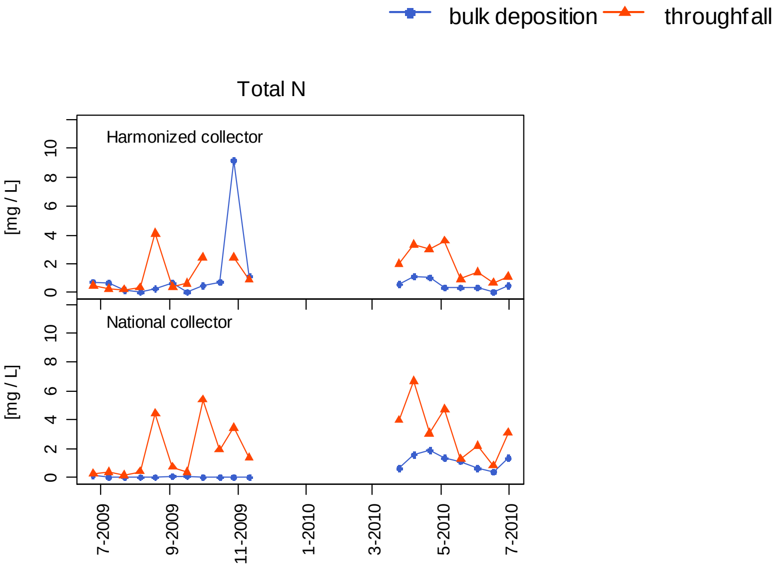
Annex 9: Time courses of the concentrations / physical properties of samples

02





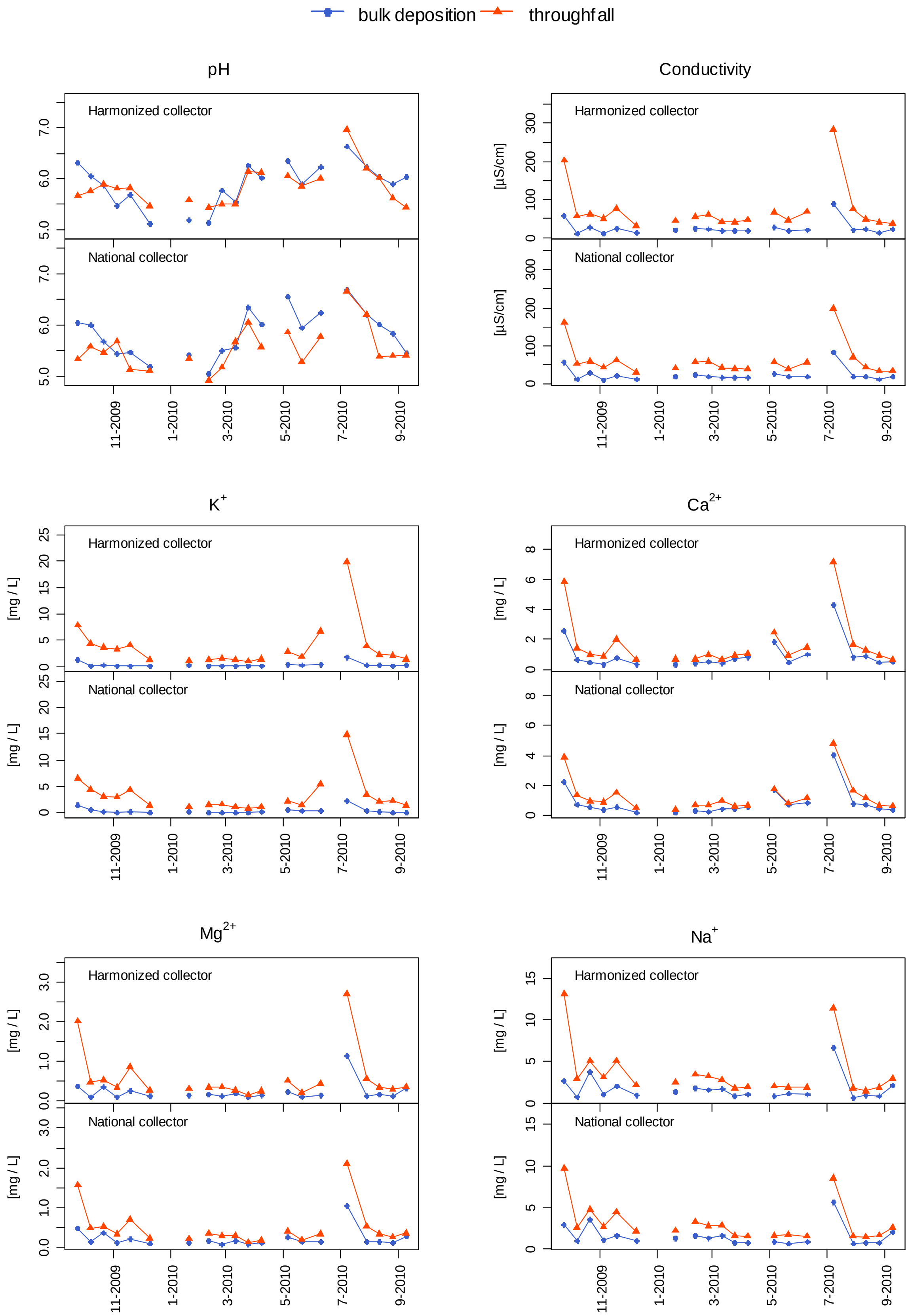
bulk deposition
throughfall
NH$_4^+$
Cl$^-$
NO$_3^-$
SO$_4^{2-}$
PO$_4^{3-}$
Alkalinity
Harmonized collector
National collector
[mg / L]
[µeq / L]
7-2009
9-2009
11-2009
1-2010
3-2010
5-2010
7-2010

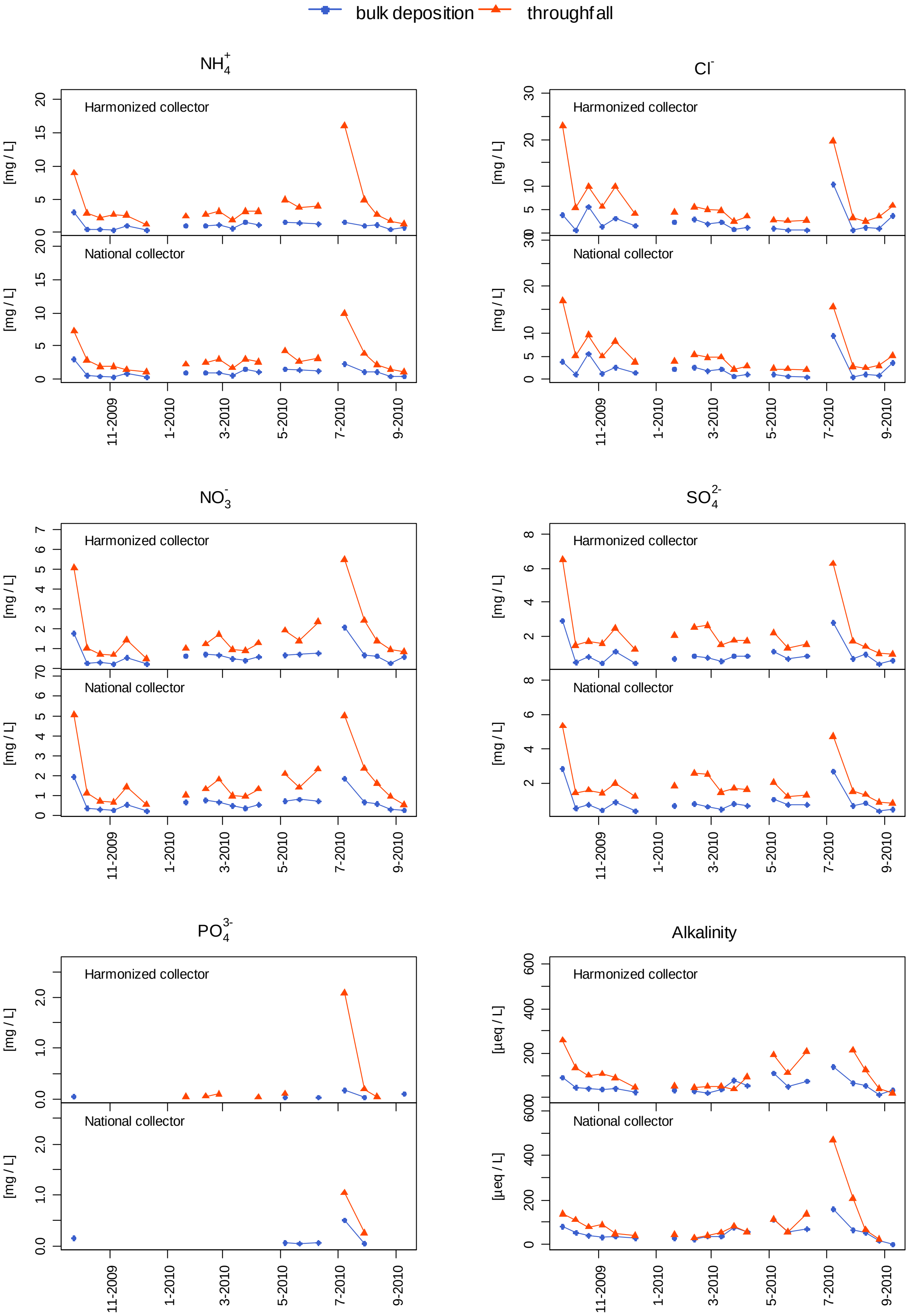

bulk deposition
throughfall
Total N
Harmonized collector
National collector
[mg / L]
[mg / L]
7-2009
9-2009
11-2009
1-2010
3-2010
5-2010
7-2010

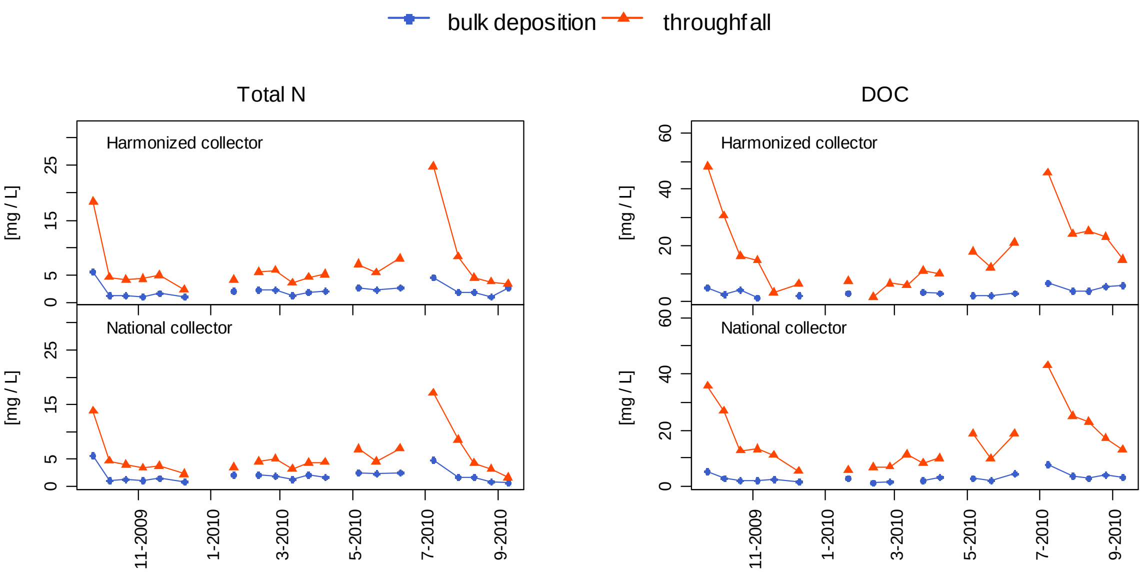
DOC

No data

03

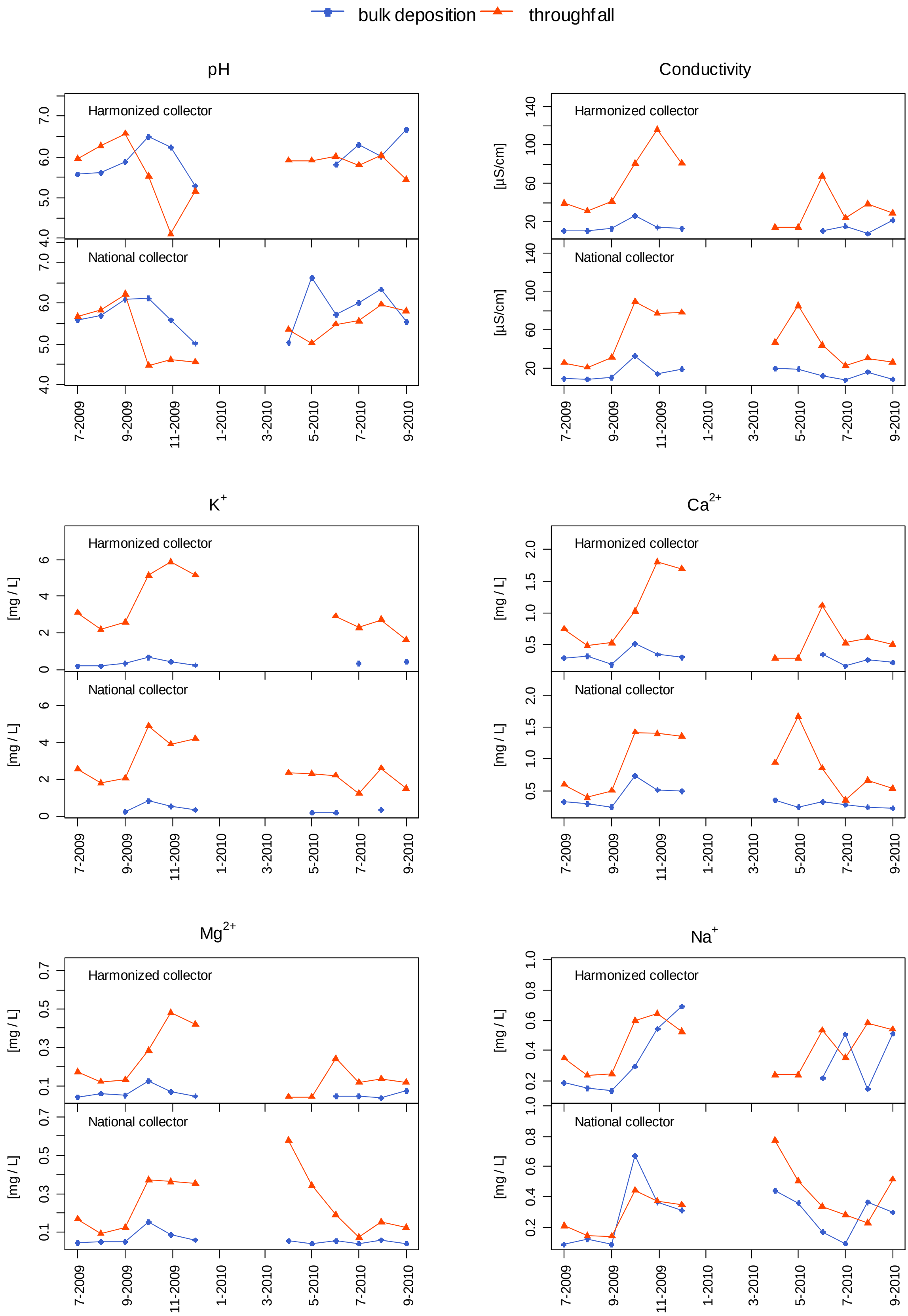

bulk deposition
throughfall
pH
Conductivity
Harmonized collector
National collector
[µS/cm]
K+
Ca2+
Mg2+
Na+
[mg / L]
11-2009
1-2010
3-2010
5-2010
7-2010
9-2010

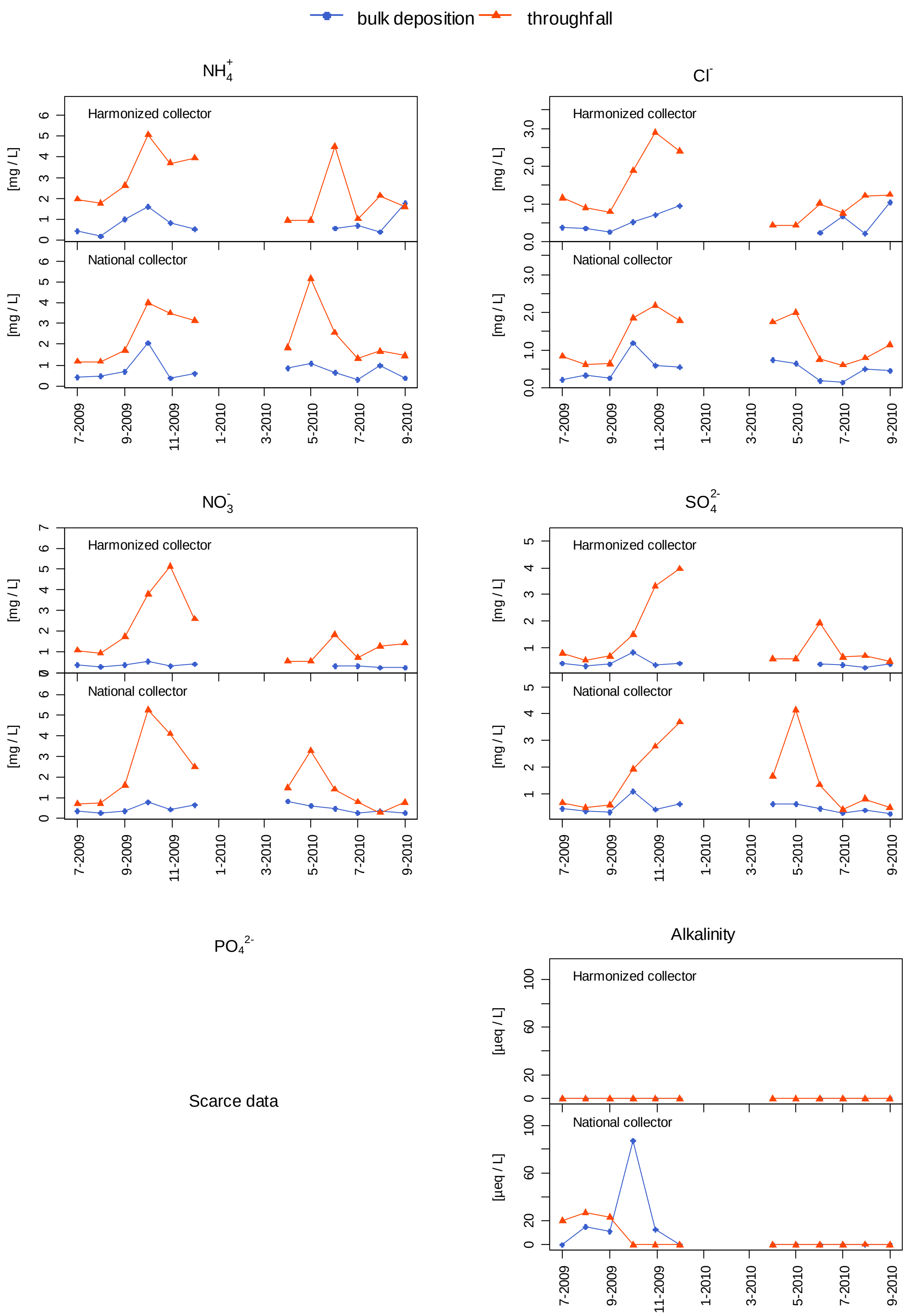

bulk deposition
throughfall
NH4+
Cl-
NO3-
SO4 2-
PO4 3-
Alkalinity
Harmonized collector
National collector
[mg / L]
[µeq / L]
11-2009
1-2010
3-2010
5-2010
7-2010
9-2010

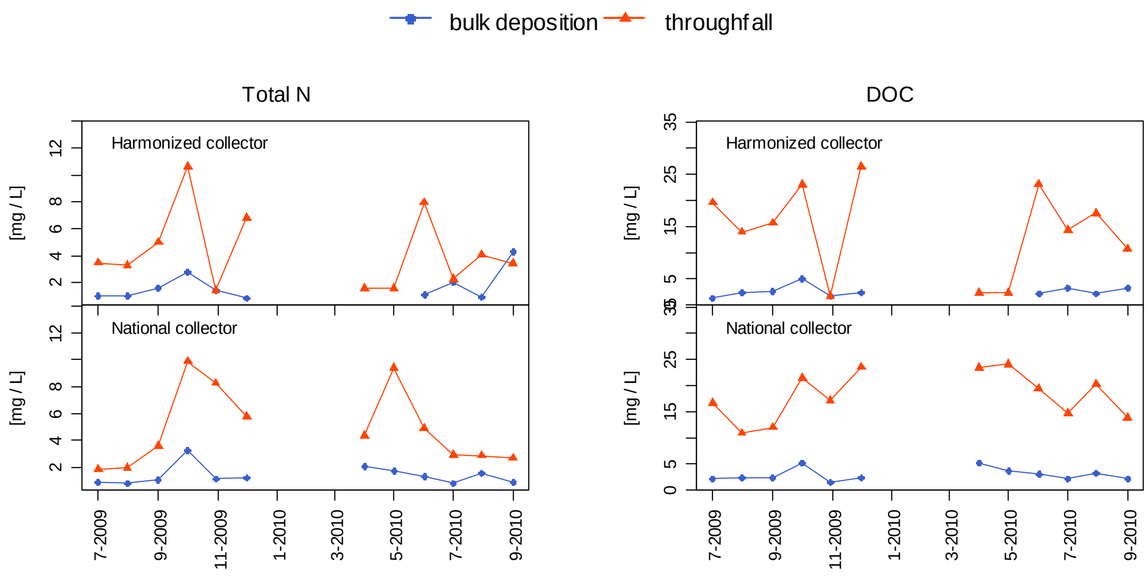


bulk deposition
throughfall
Total N
DOC
Harmonized collector
National collector
[mg / L]
11-2009
1-2010
3-2010
5-2010
7-2010
9-2010

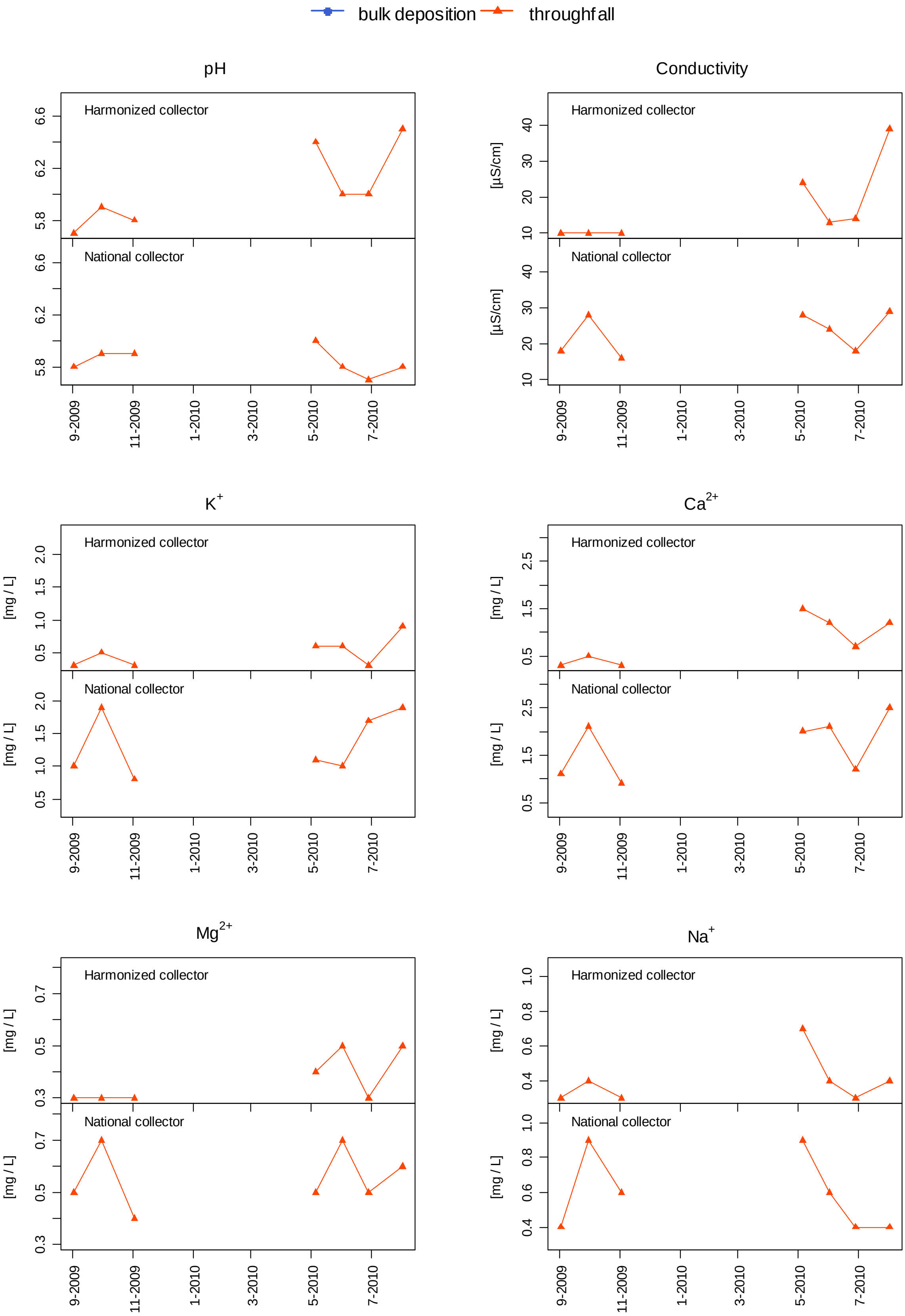
07

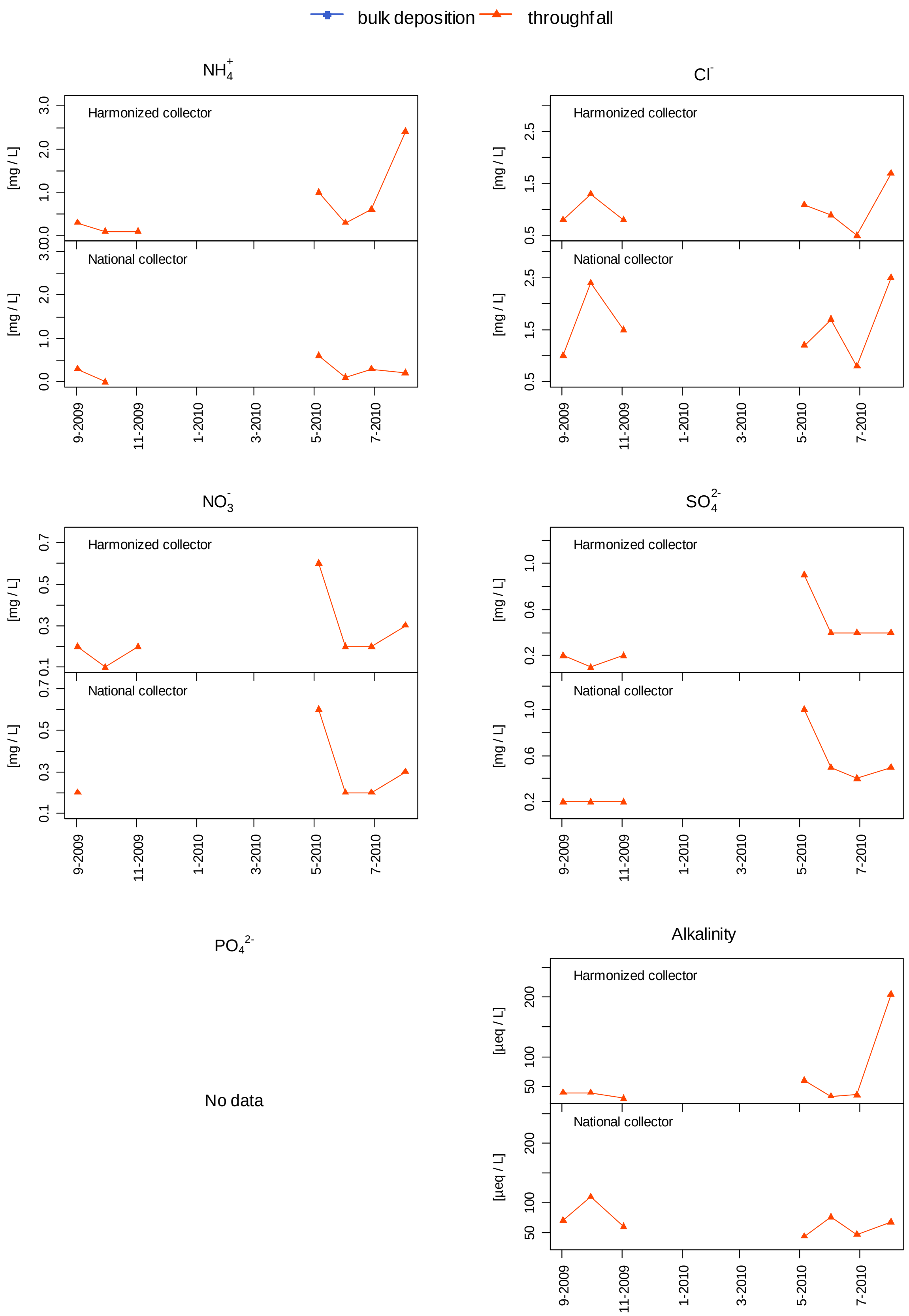

bulk deposition
throughfall
pH
Conductivity
K+
Ca2+
Mg2+
Na+
Harmonized collector
National collector
[µS/cm]
[mg / L]
7-2009
9-2009
11-2009
1-2010
3-2010
5-2010
7-2010
9-2010

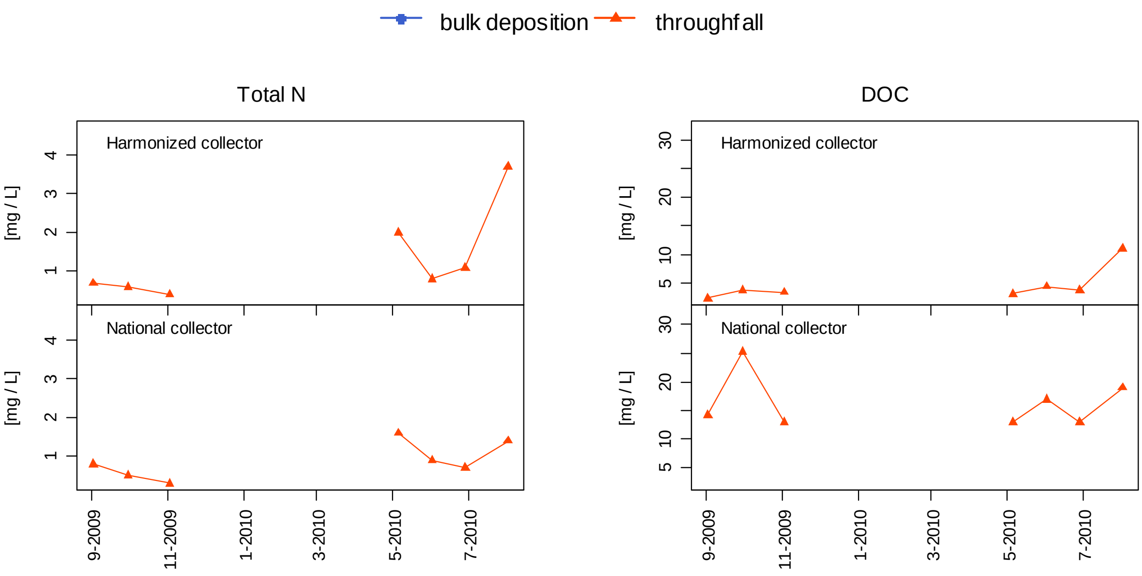

bulk deposition
throughfall
NH4+
Cl-
NO3-
SO4 2-
PO4 2-
Alkalinity
Harmonized collector
National collector
[mg / L]
[µeq / L]
Scarce data
7-2009
9-2009
11-2009
1-2010
3-2010
5-2010
7-2010
9-2010


bulk deposition
throughfall
Total N
DOC
Harmonized collector
National collector
[mg / L]
7-2009
9-2009
11-2009
1-2010
3-2010
5-2010
7-2010
9-2010

09

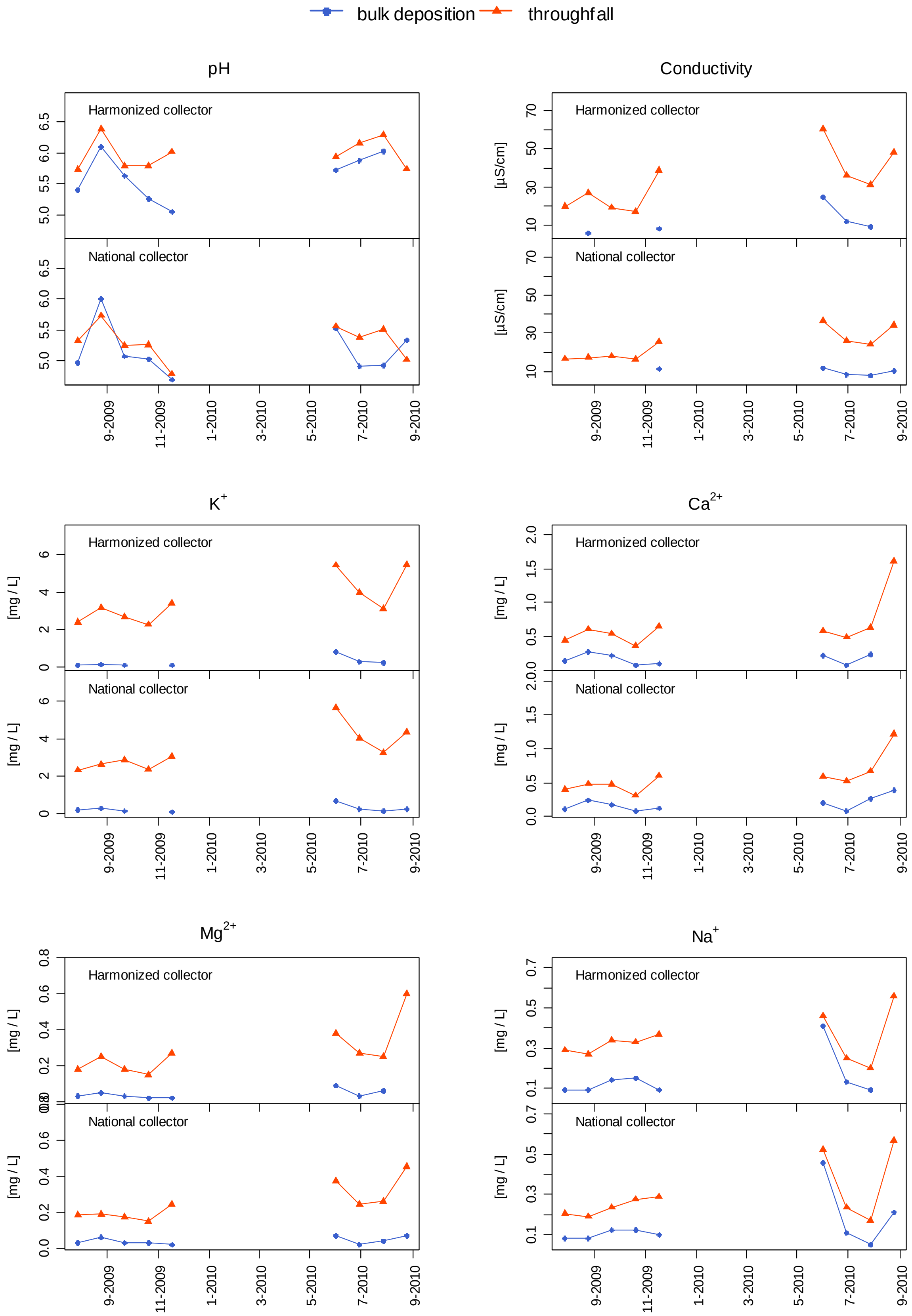

bulk deposition
throughfall
pH
Conductivity
K+
Ca2+
Mg2+
Na+
Harmonized collector
National collector
[µS/cm]
[mg / L]
9-2009
11-2009
1-2010
3-2010
5-2010
7-2010

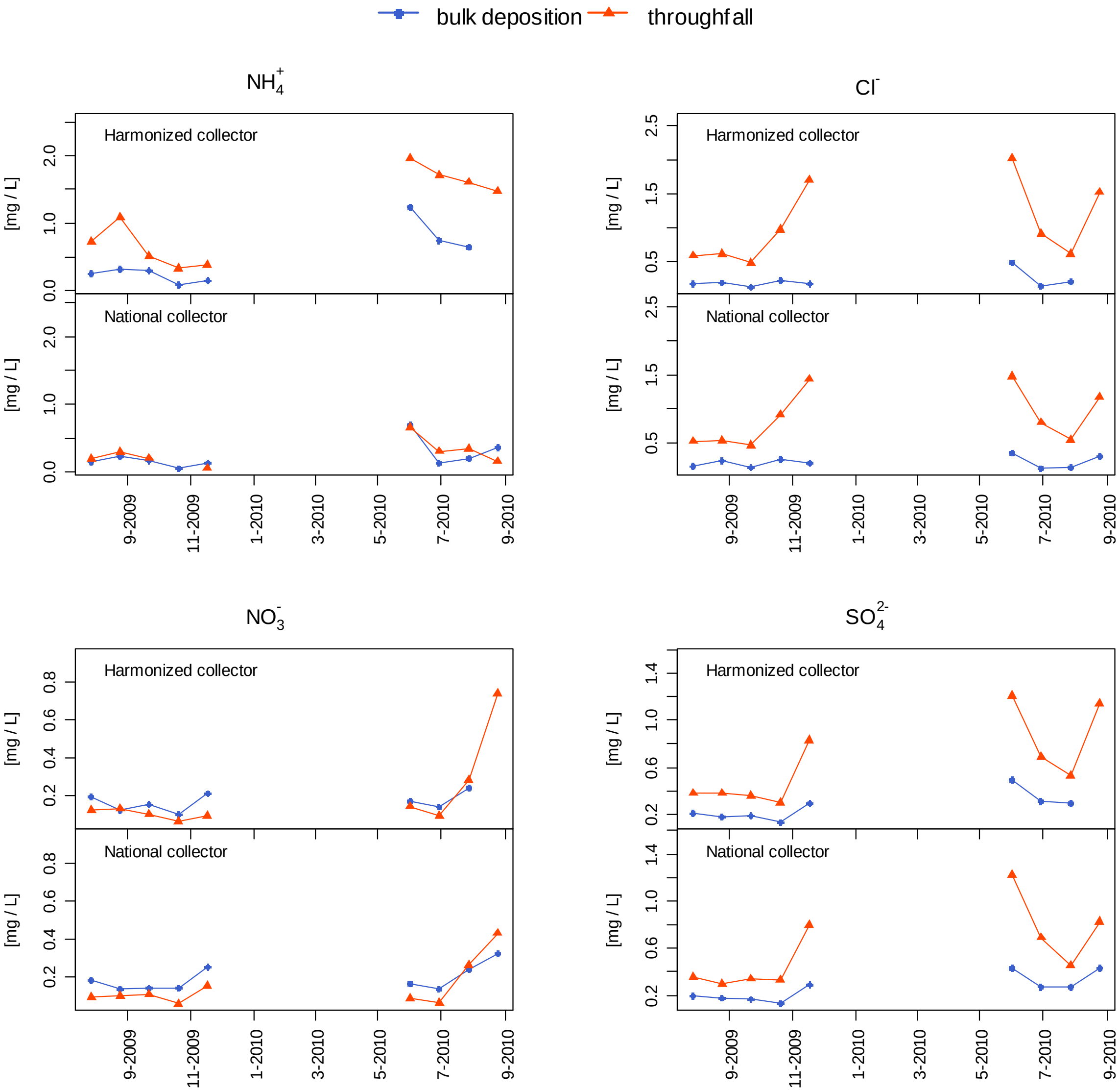

bulk deposition
throughfall
NH4+
Cl-
NO3-
SO42-
PO42-
No data
Alkalinity
Harmonized collector
National collector
[mg / L]
[µeq / L]
9-2009
11-2009
1-2010
3-2010
5-2010
7-2010



bulk deposition
throughfall
Total N
DOC
Harmonized collector
National collector
[mg / L]
9-2009
11-2009
1-2010
3-2010
5-2010
7-2010

10


bulk deposition
throughfall
pH
Conductivity
K+
Ca2+
Mg2+
Na+
Harmonized collector
National collector
[µS/cm]
[mg / L]
9-2009
11-2009
1-2010
3-2010
5-2010
7-2010
9-2010

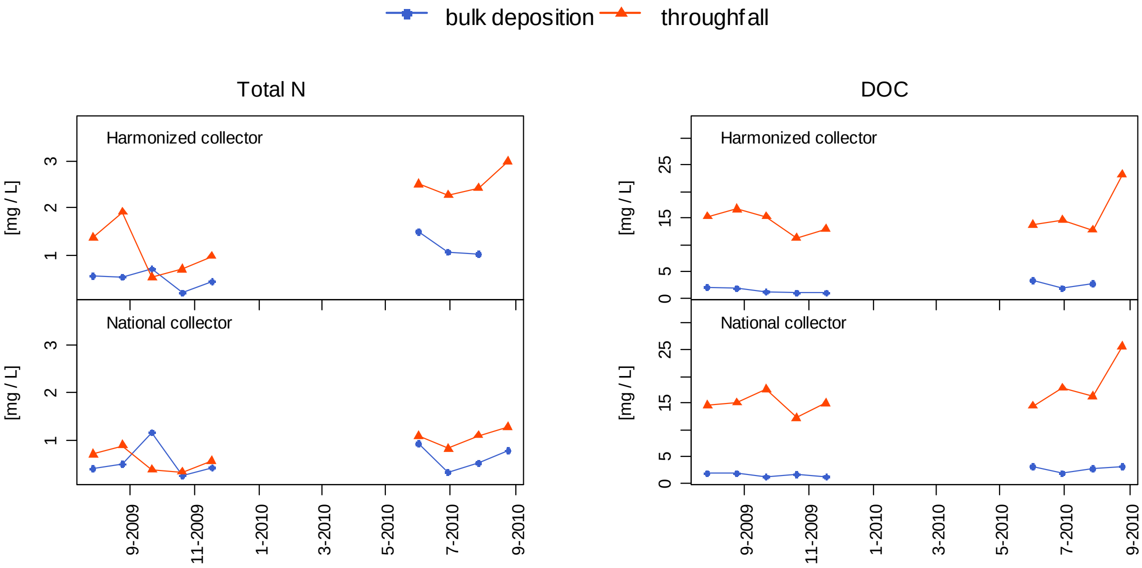


PO_4^{2-}

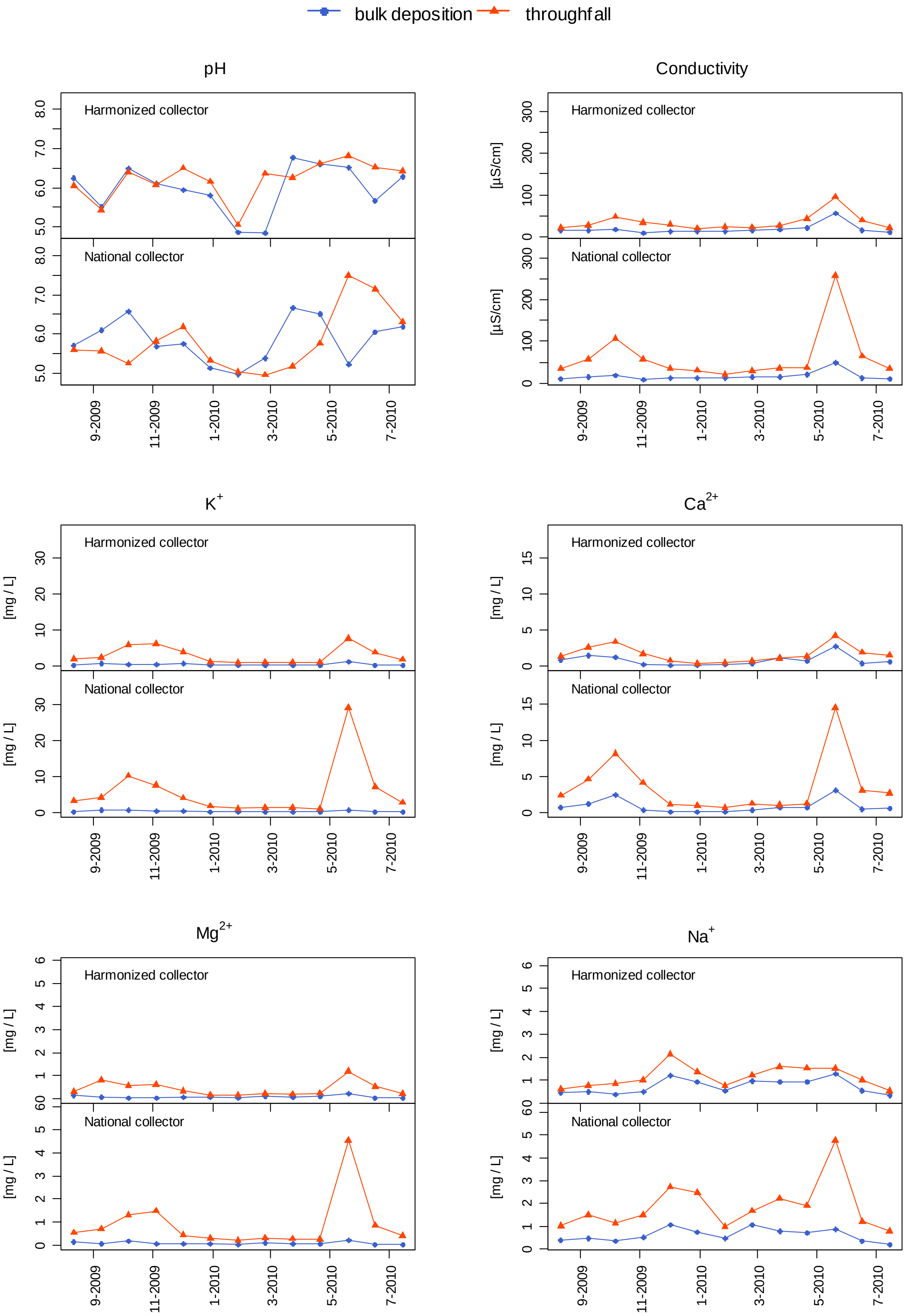
Scarce data

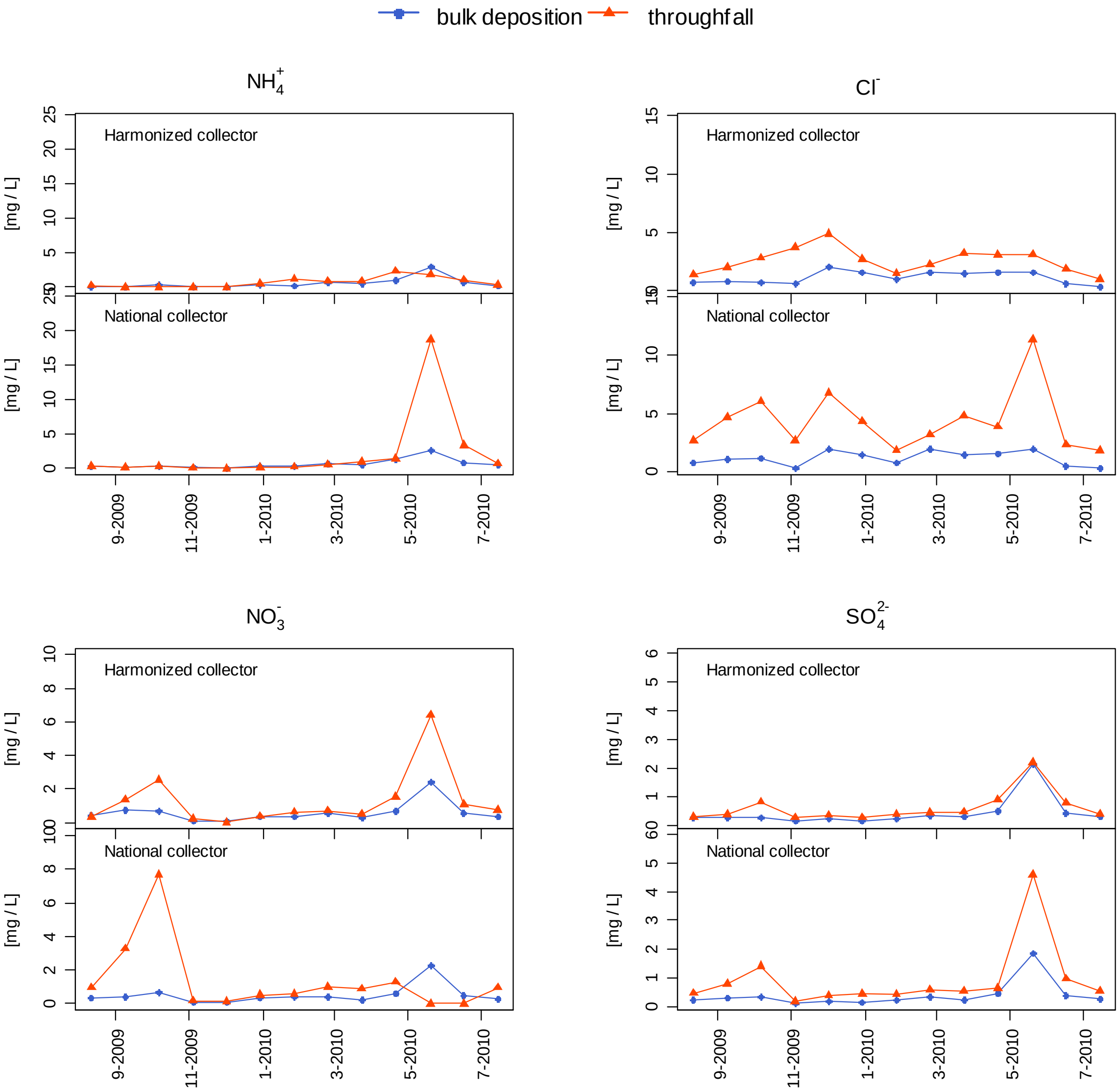
Alkalinity

Scarce data


bulk deposition
throughfall
Total N
DOC
Harmonized collector
National collector
Harmonized collector
National collector
[mg / L]
[mg / L]
[mg / L]
[mg / L]
9-2009
11-2009
1-2010
3-2010
5-2010
7-2010
9-2010
9-2009
11-2009
1-2010
3-2010
5-2010
7-2010
9-2010

11


bulk deposition
throughfall
pH
Harmonized collector
National collector
8.0
7.0
6.0
5.0
9-2009
11-2009
1-2010
3-2010
5-2010
7-2010
Conductivity
[µS/cm]
0
100
200
300
K+
Ca2+
Mg2+
Na+
[mg / L]
0
10
20
30
5
15
1
2
3
4
6

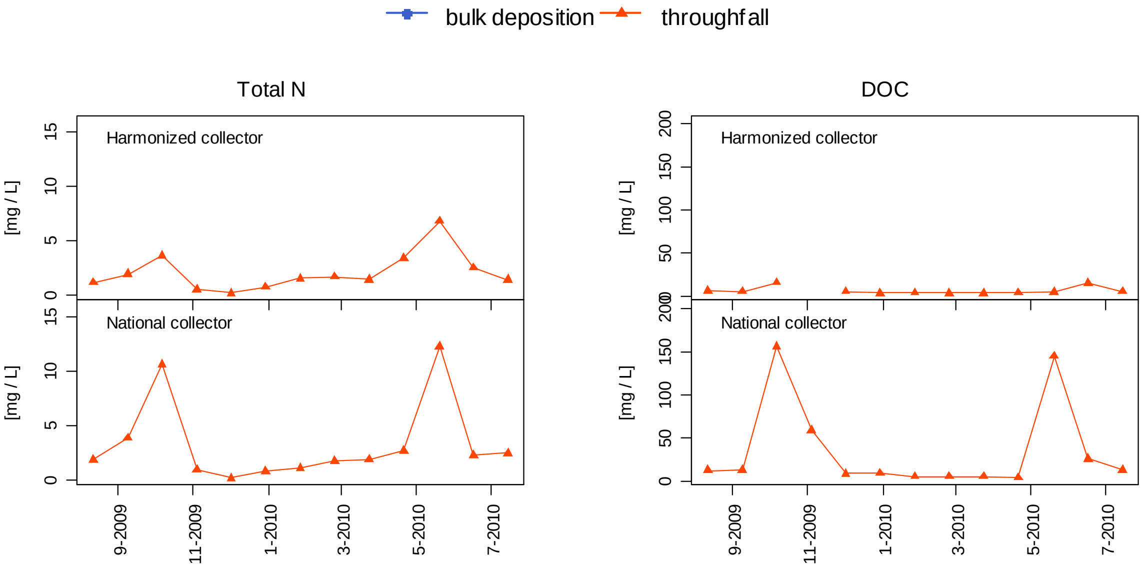


PO_4^{2-}

Alkalinity

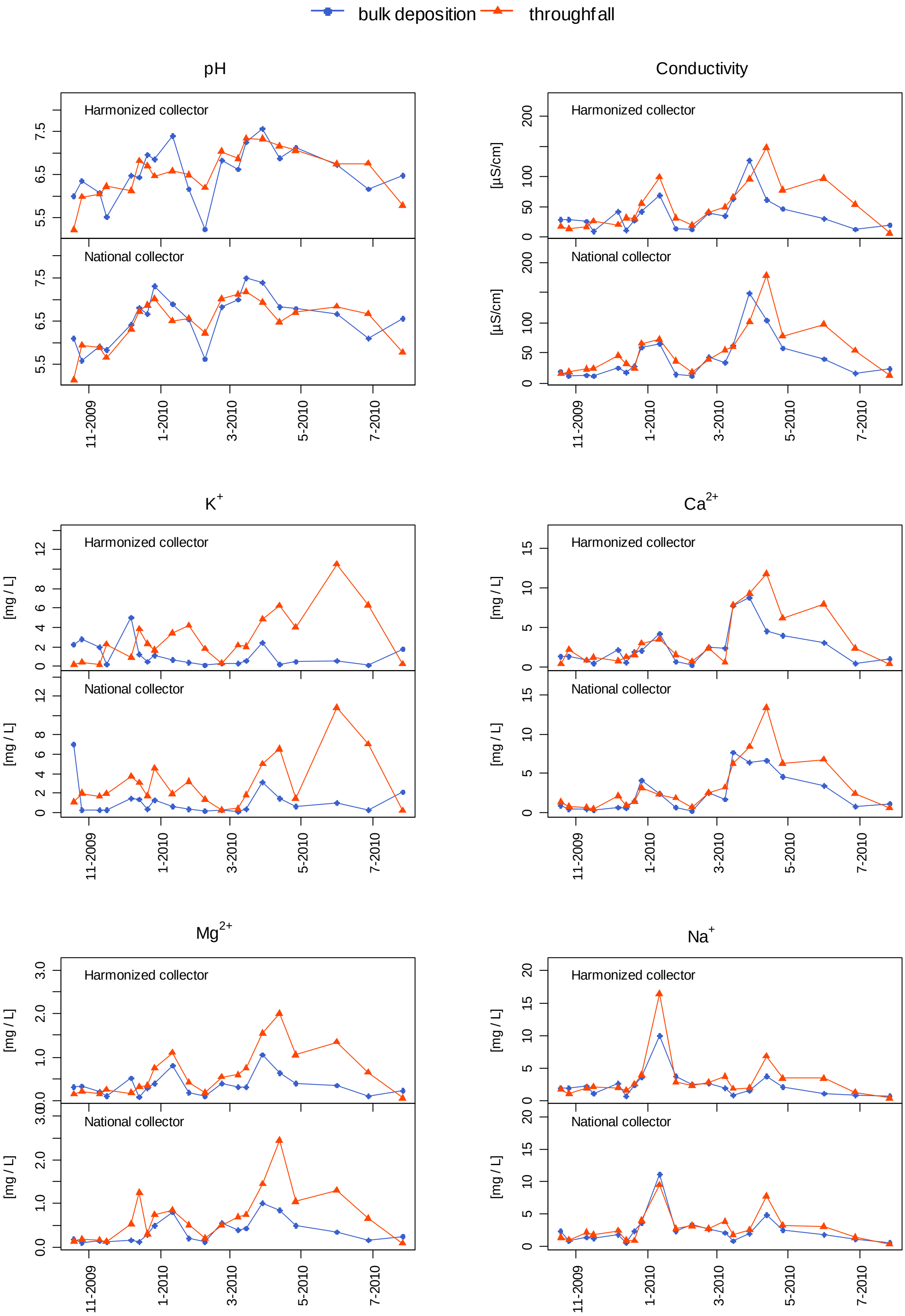
Scarce data

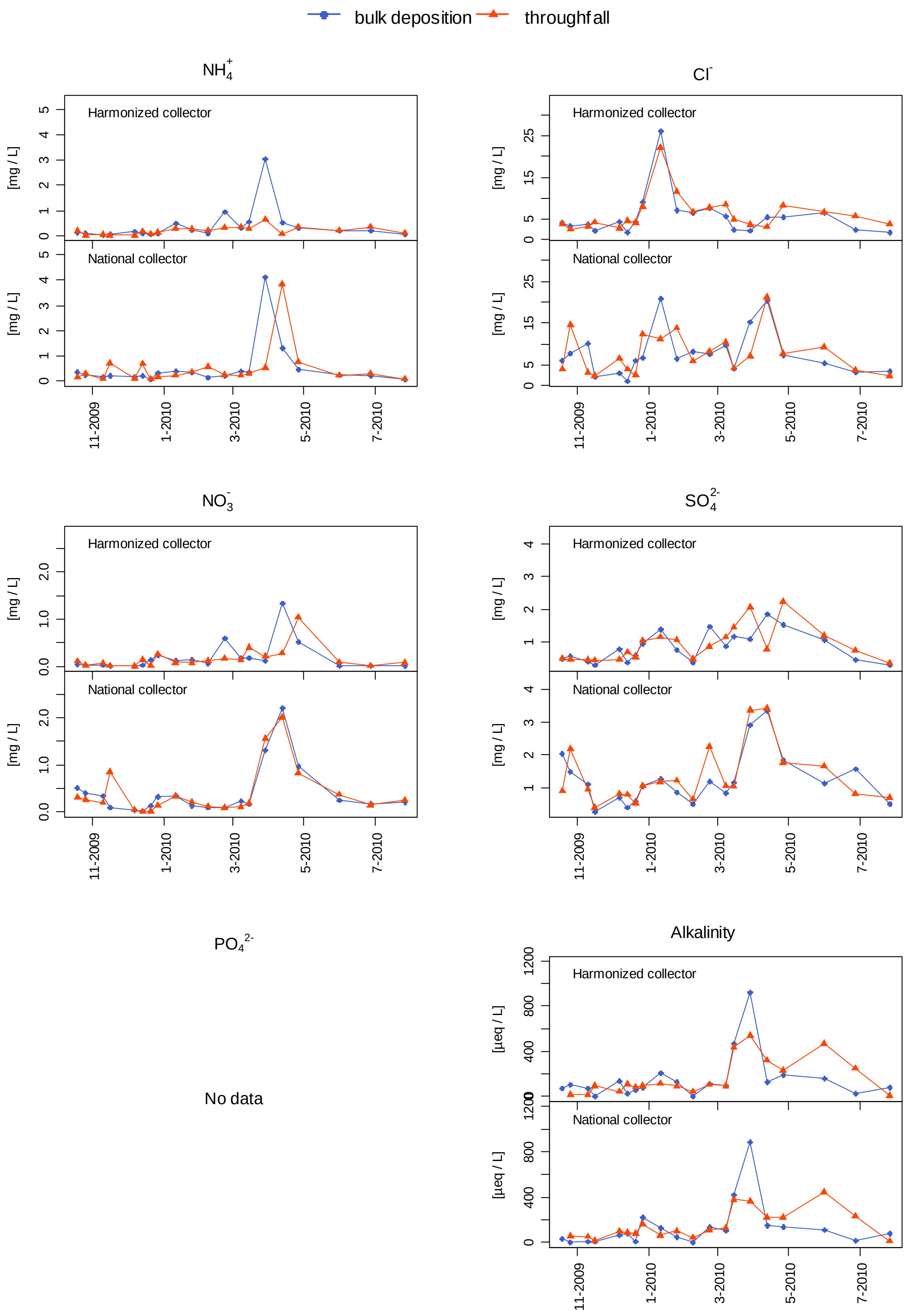
Scarce data

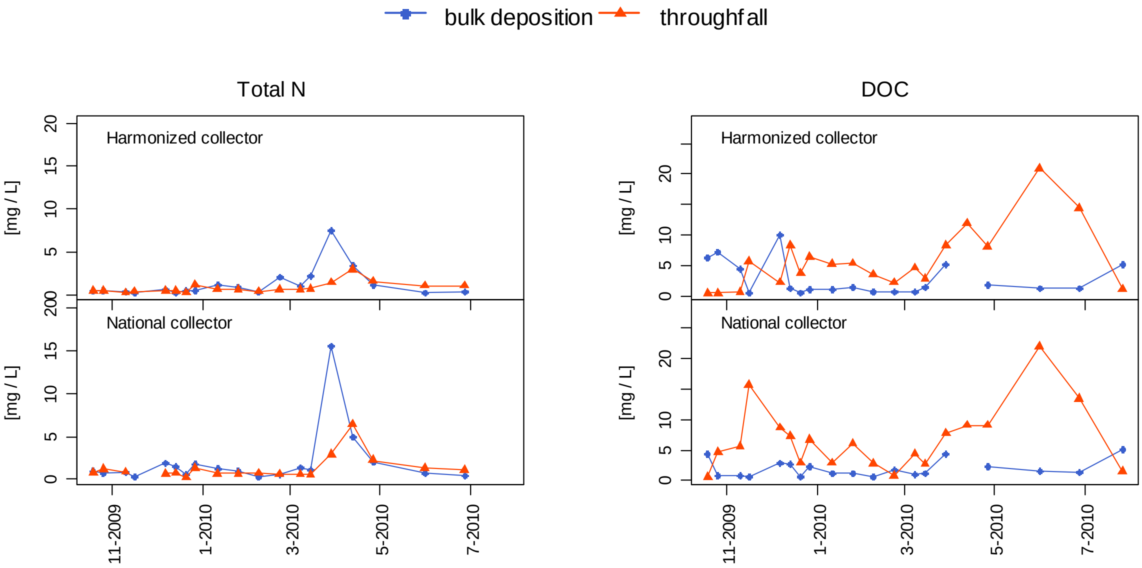


bulk deposition
throughfall
Total N
DOC
Harmonized collector
National collector
[mg / L]
0
5
10
15
50
100
150
200
9-2009
11-2009
1-2010
3-2010
5-2010
7-2010

12

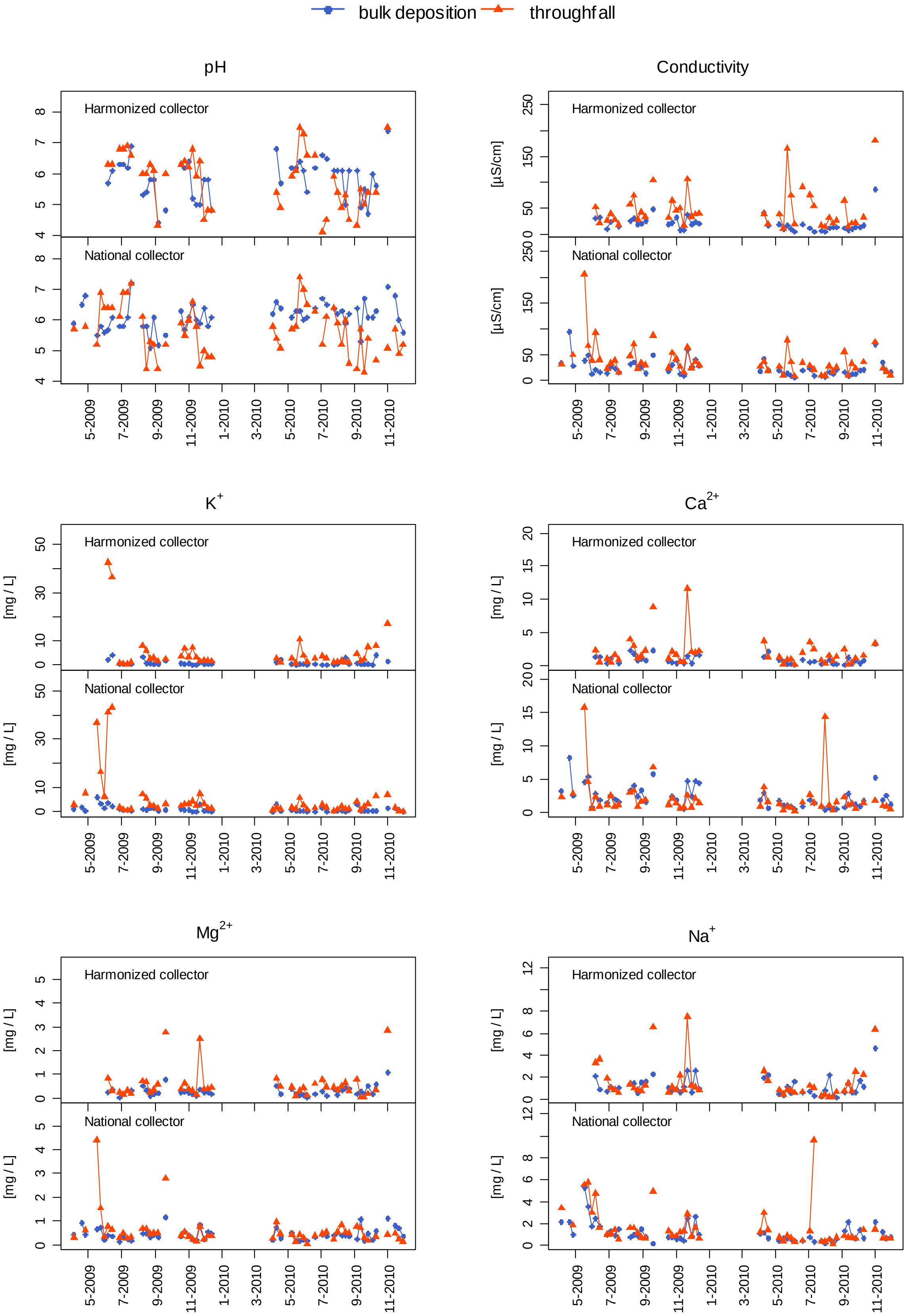

bulk deposition
throughfall
pH
Harmonized collector
National collector
Conductivity
[µS/cm]
K+
Ca2+
Mg2+
Na+
[mg / L]
11-2009
1-2010
3-2010
5-2010
7-2010

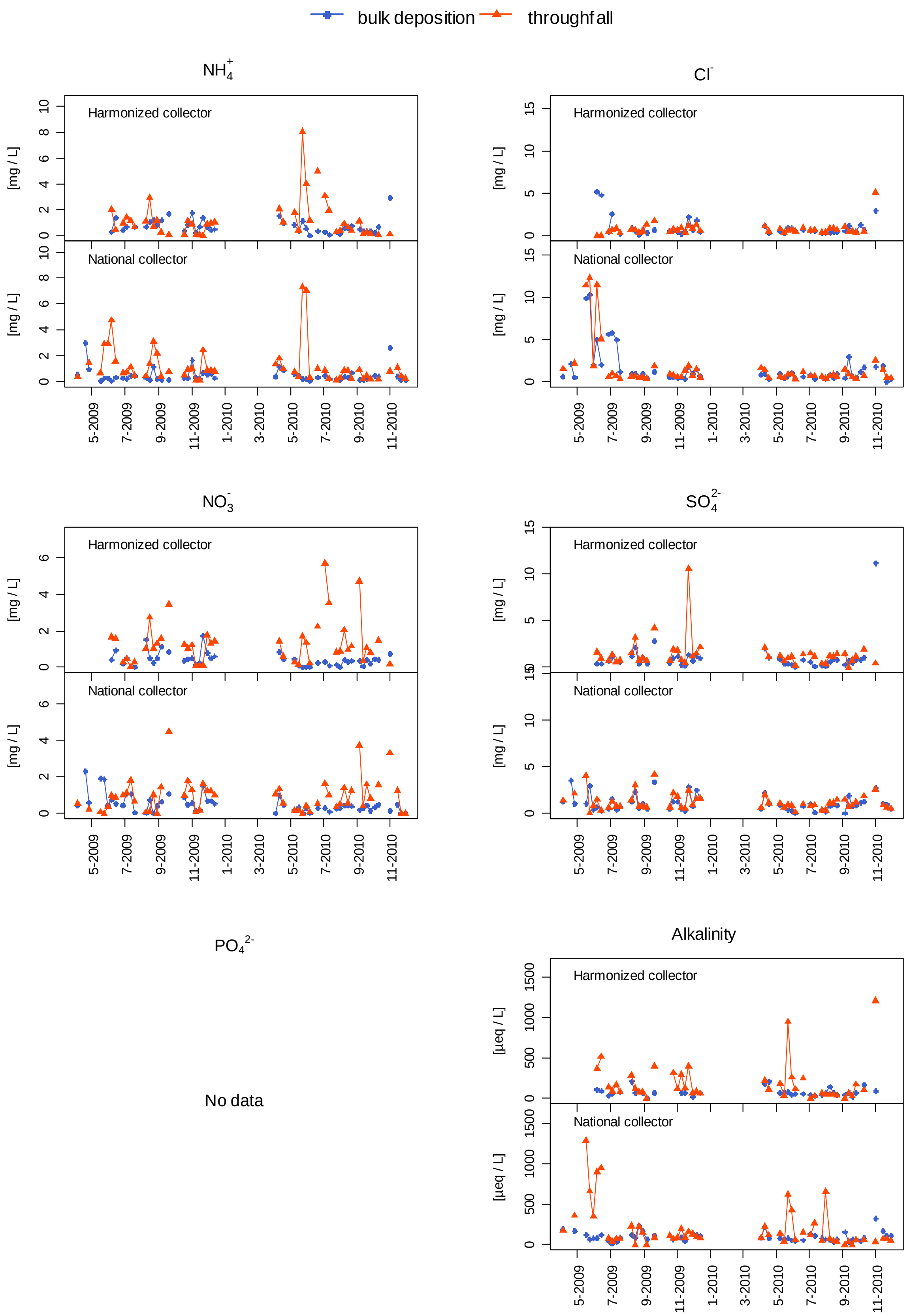

bulk deposition
throughfall
NH4+
Cl-
NO3-
SO4 2-
PO4 2-
Alkalinity
Harmonized collector
National collector
[mg / L]
[µeq / L]
No data
11-2009
1-2010
3-2010
5-2010
7-2010



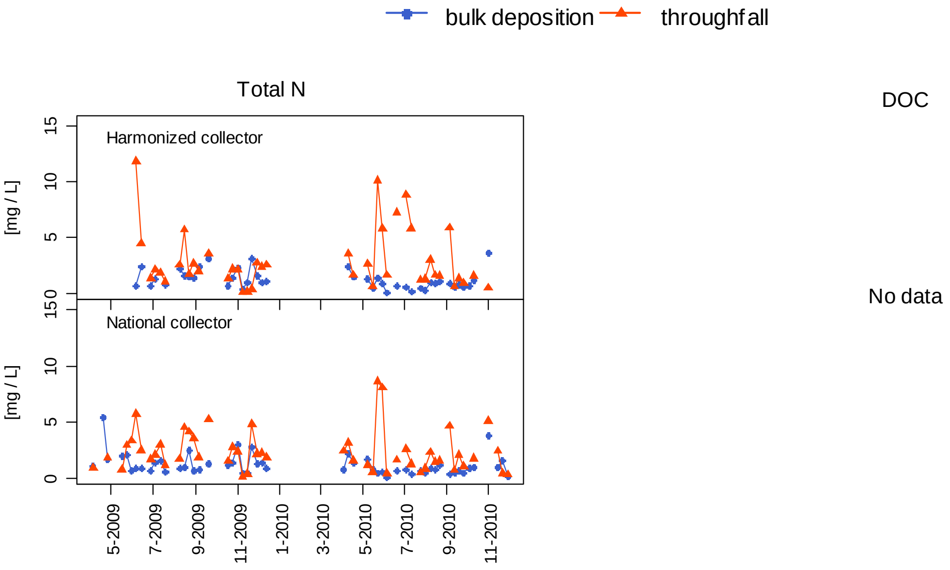
bulk deposition
throughfall
Total N
DOC
Harmonized collector
National collector
[mg / L]
11-2009
1-2010
3-2010
5-2010
7-2010

13

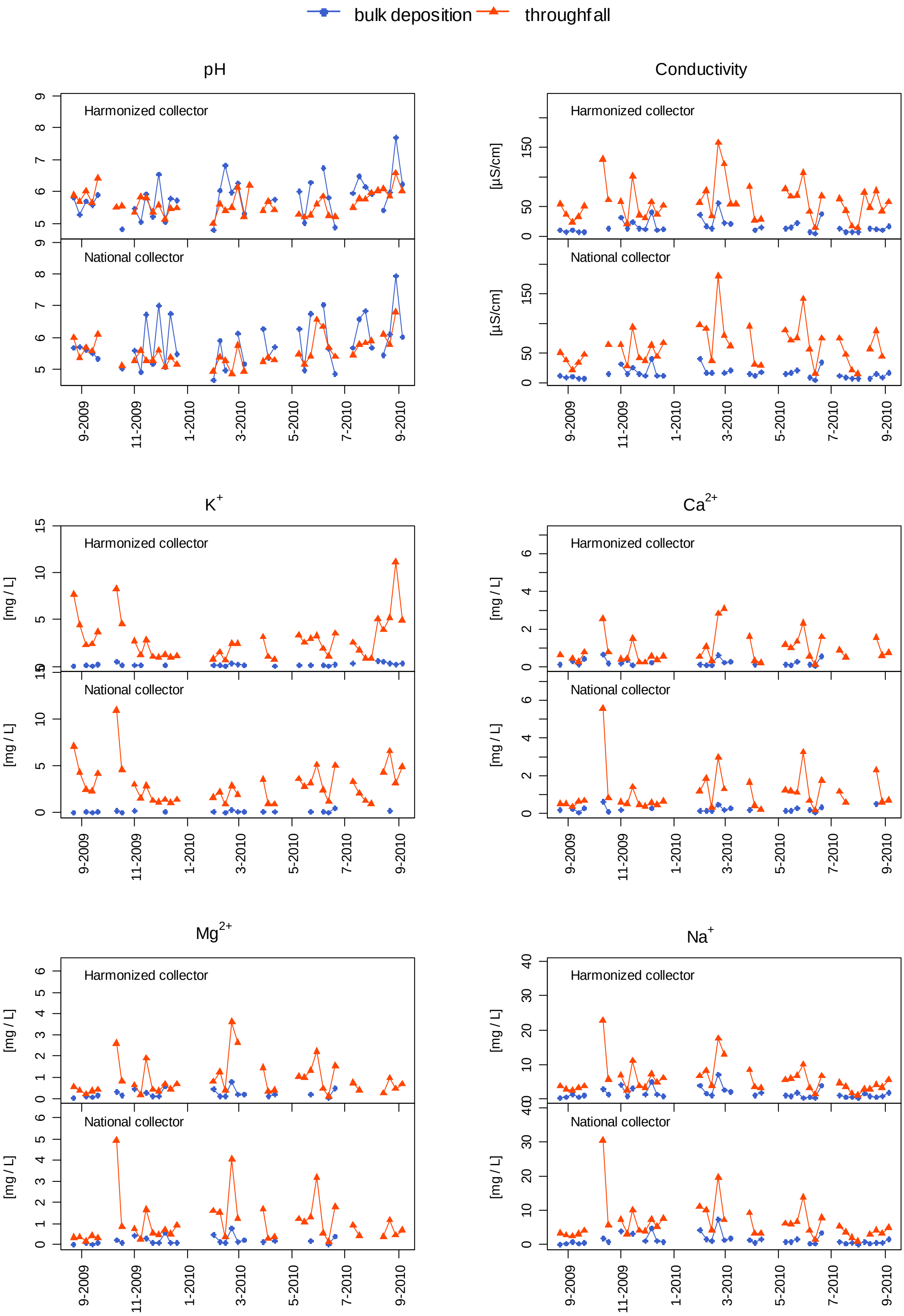

bulk deposition
throughfall
pH
Conductivity
K+
Ca2+
Mg2+
Na+
Harmonized collector
National collector
[µS/cm]
[mg / L]
5-2009
7-2009
9-2009
11-2009
1-2010
3-2010
5-2010
7-2010
9-2010
11-2010

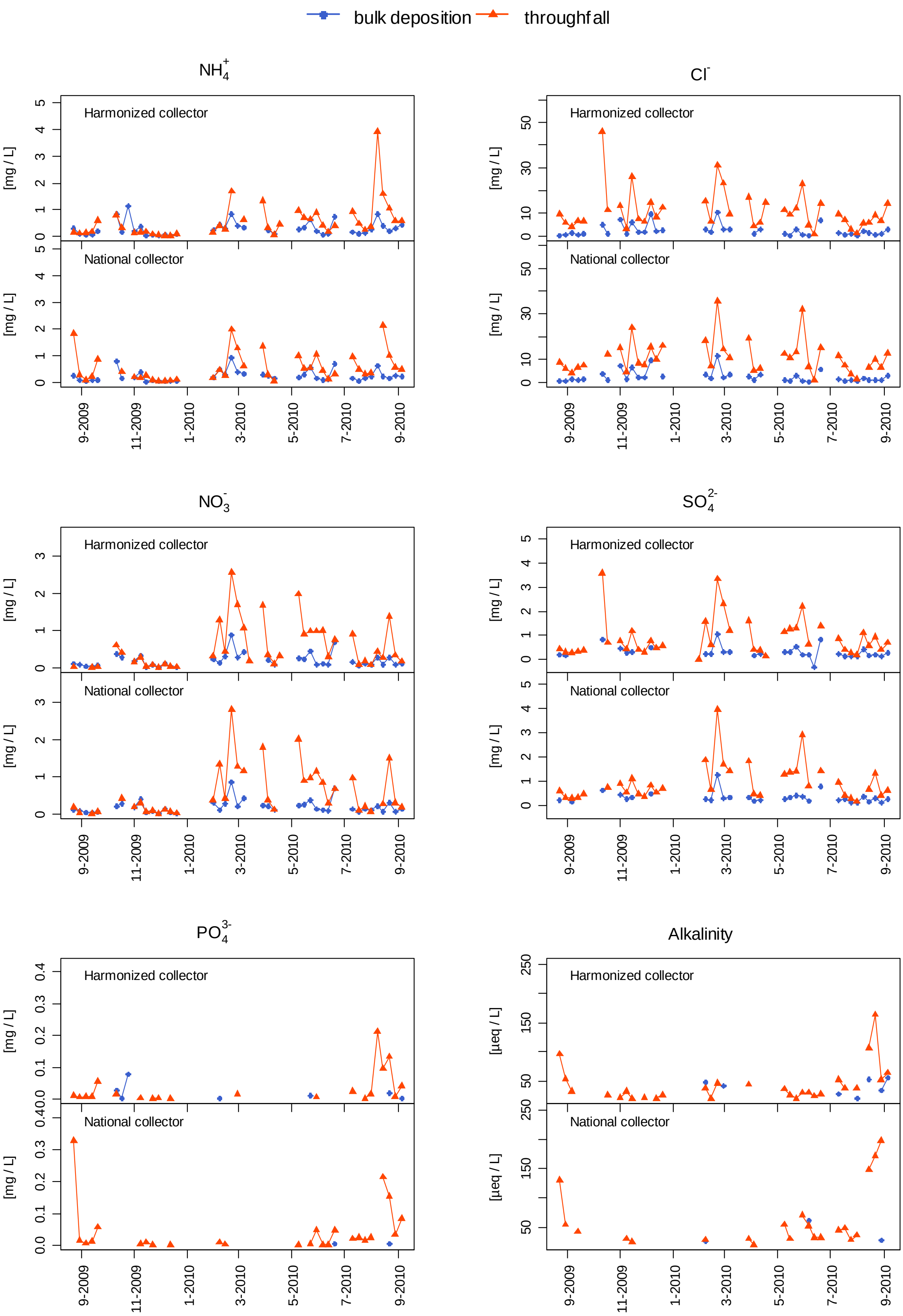


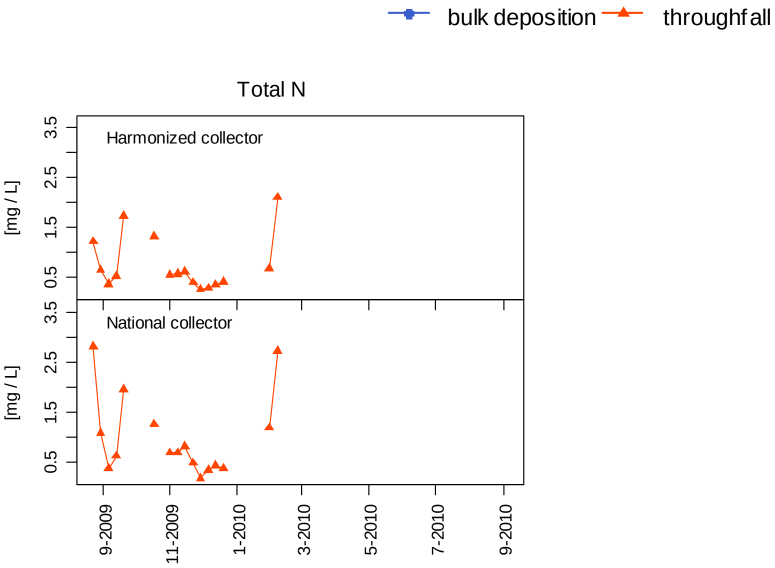
bulk deposition
throughfall
NH4+
Cl-
NO3-
SO4 2-
PO4 2-
Alkalinity
Harmonized collector
National collector
[mg / L]
[µeq / L]
No data
5-2009
7-2009
9-2009
11-2009
1-2010
3-2010
5-2010
7-2010
9-2010
11-2010


bulk deposition
throughfall
Total N
Harmonized collector
National collector
[mg / L]
[mg / L]
5-2009
7-2009
9-2009
11-2009
1-2010
3-2010
5-2010
7-2010
9-2010
11-2010
DOC
No data

14


bulk deposition
throughfall
pH
Conductivity
K+
Ca2+
Mg2+
Na+
Harmonized collector
National collector
[µS/cm]
[mg / L]
9-2009
11-2009
1-2010
3-2010
5-2010
7-2010
9-2010


bulk deposition
throughfall
NH_4^+
Cl^-
NO_3^-
SO_4^{2-}
PO_4^{3-}
Alkalinity
Harmonized collector
National collector
[mg / L]
[µeq / L]
9-2009
11-2009
1-2010
3-2010
5-2010
7-2010
9-2010

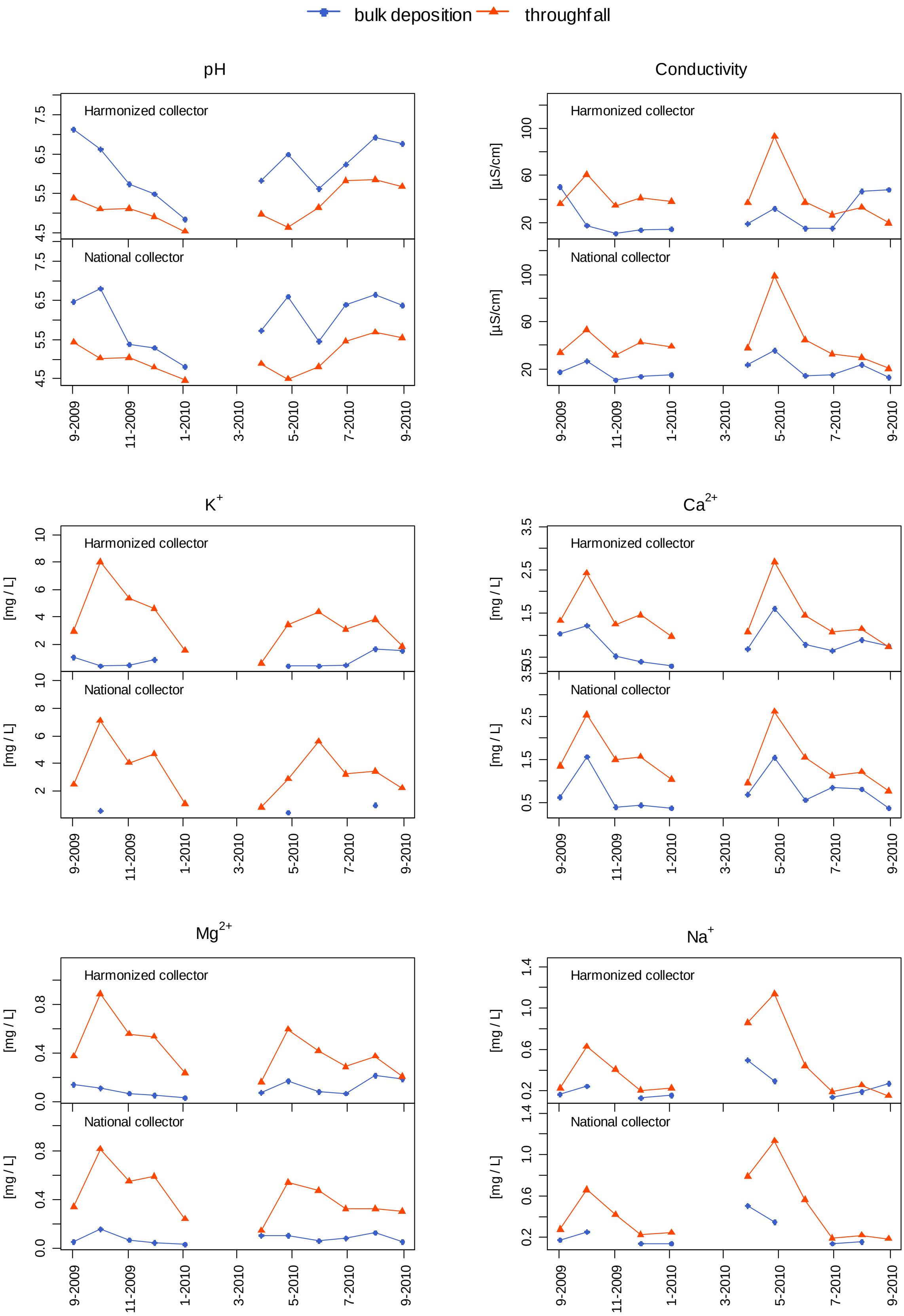


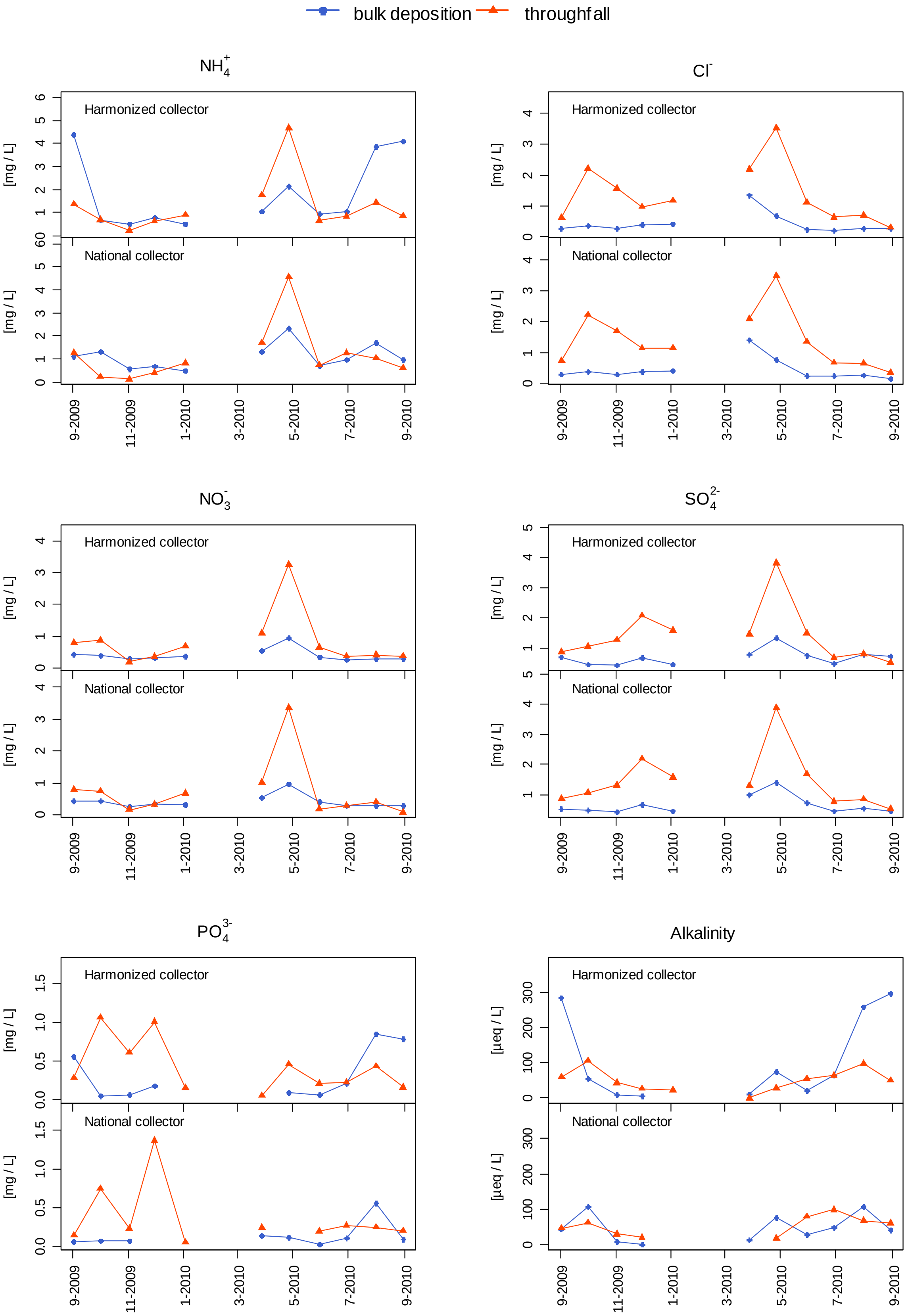
bulk deposition
throughfall
Total N
Harmonized collector
National collector
[mg / L]
0.5
1.5
2.5
3.5
9-2009
11-2009
1-2010
3-2010
5-2010
7-2010
9-2010

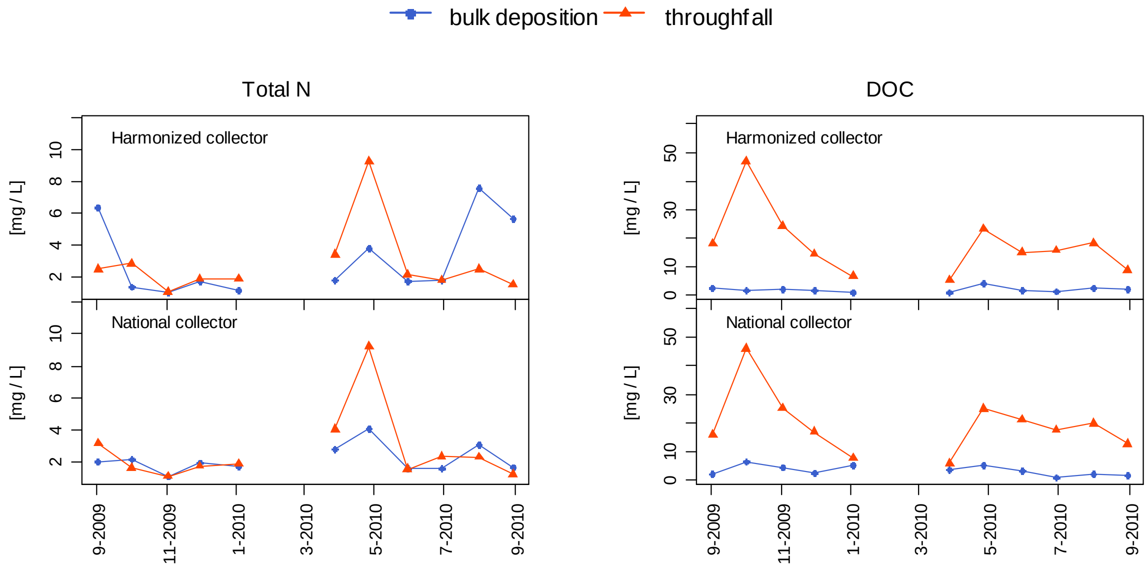
DOC

No data

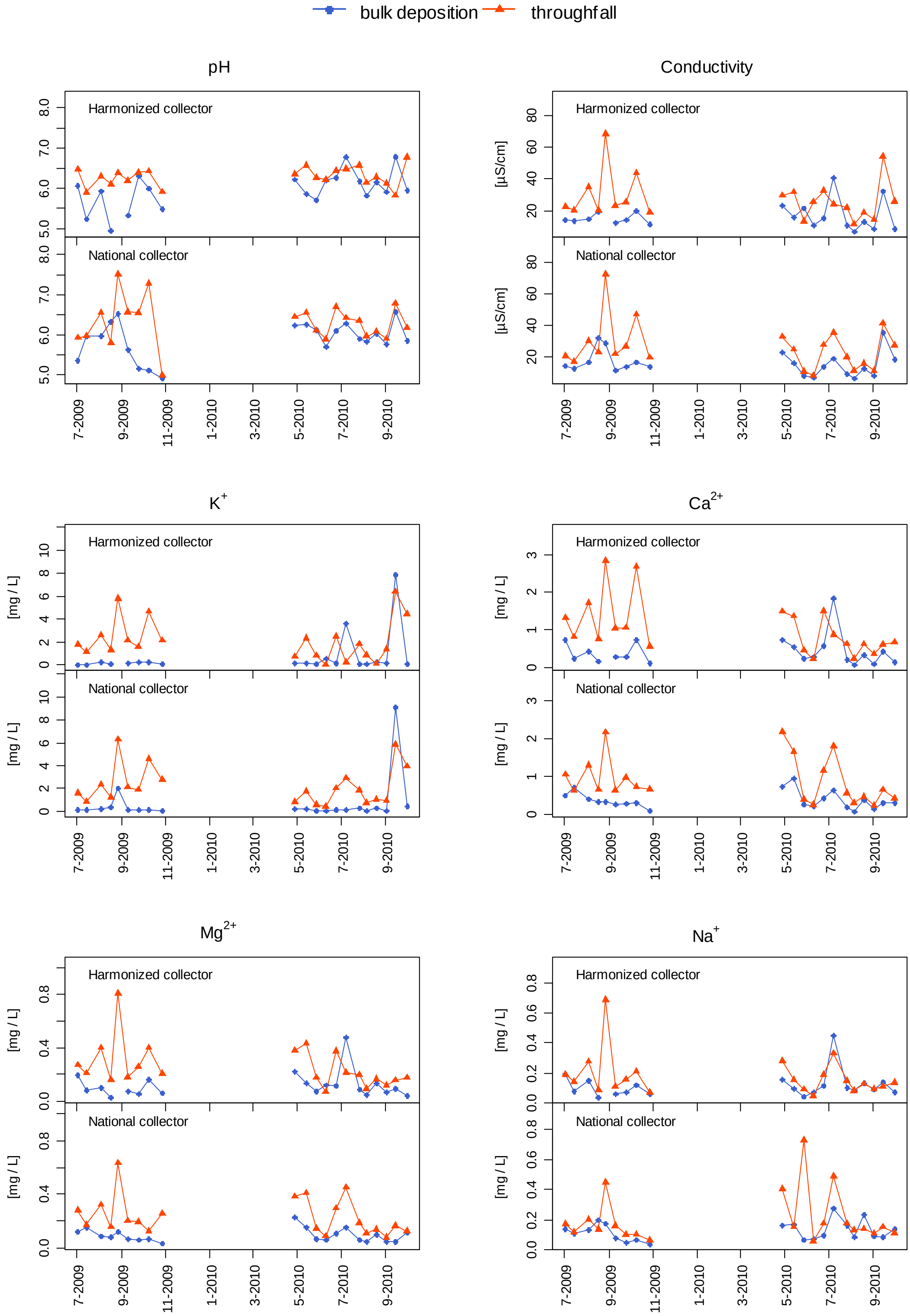
18


bulk deposition
throughfall
pH
Conductivity
K+
Ca2+
Mg2+
Na+
Harmonized collector
National collector
[µS/cm]
[mg / L]
9-2009
11-2009
1-2010
3-2010
5-2010
7-2010
9-2010

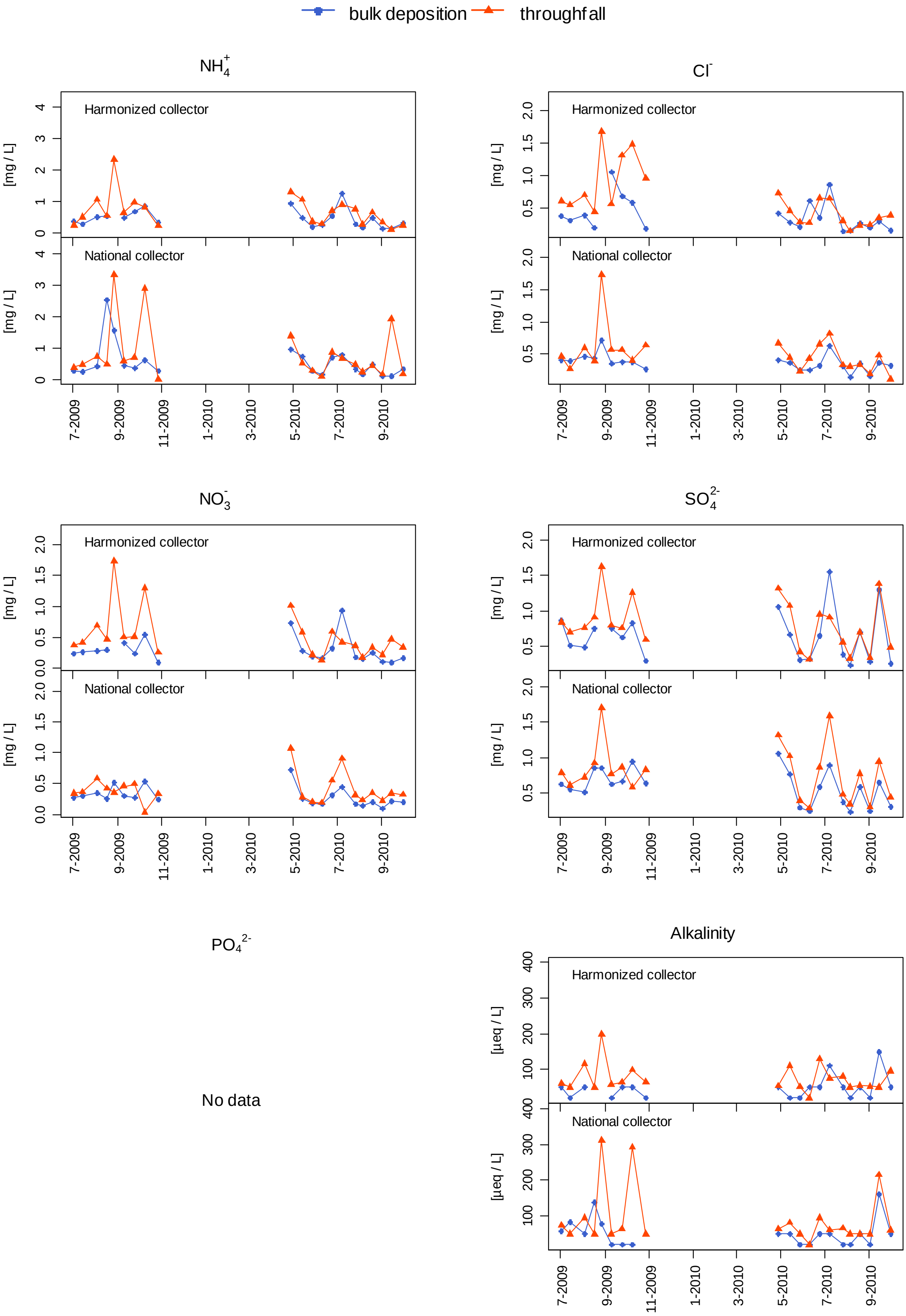

bulk deposition
throughfall
NH4+
Cl-
NO3-
SO4 2-
PO4 3-
Alkalinity
Harmonized collector
National collector
[mg / L]
[µeq / L]
9-2009
11-2009
1-2010
3-2010
5-2010
7-2010
9-2010

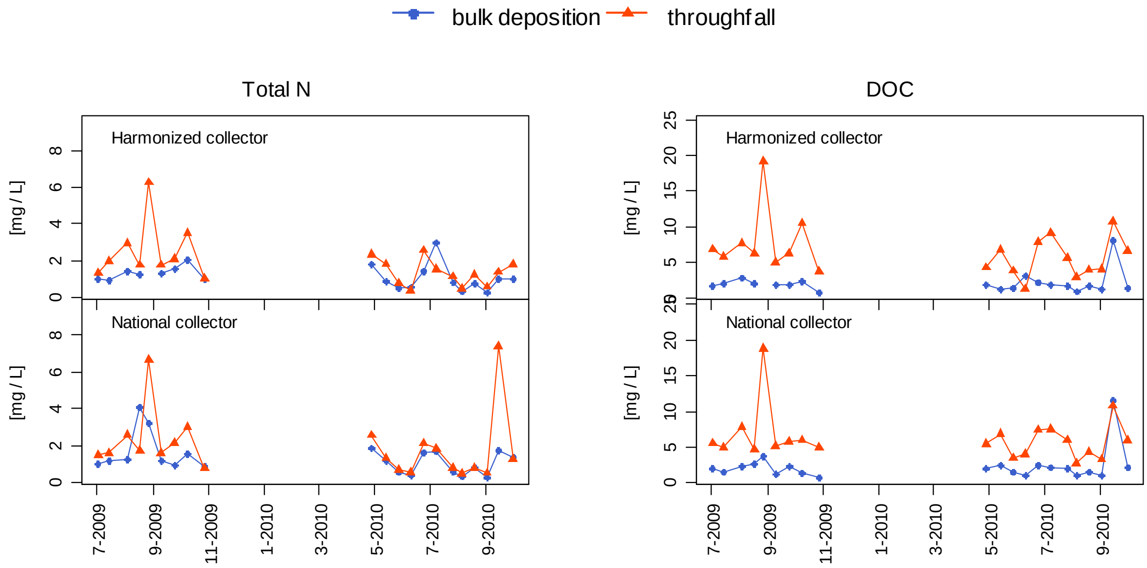

bulk deposition
throughfall
Total N
DOC
Harmonized collector
National collector
[mg / L]
9-2009
11-2009
1-2010
3-2010
5-2010
7-2010
9-2010

21

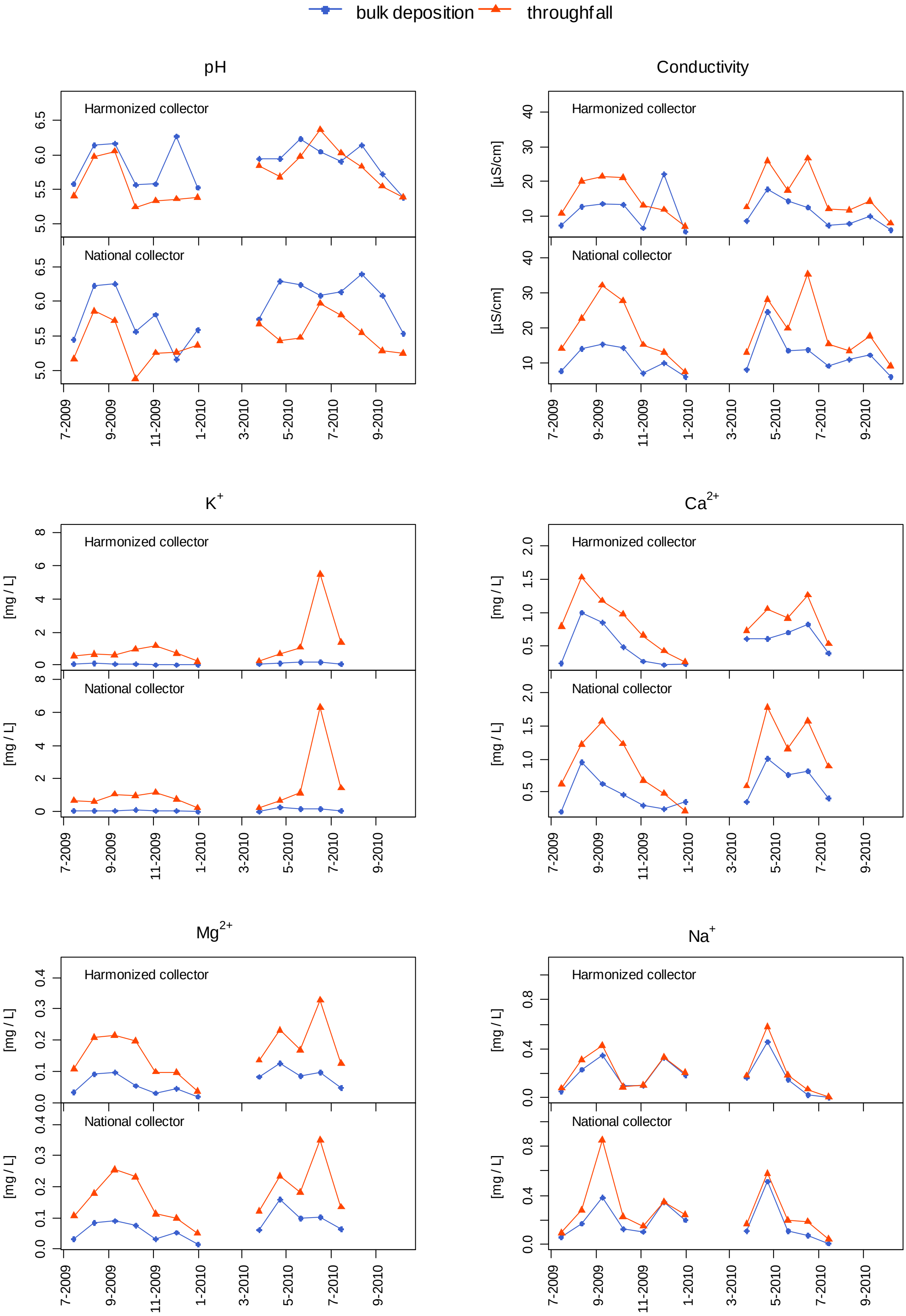


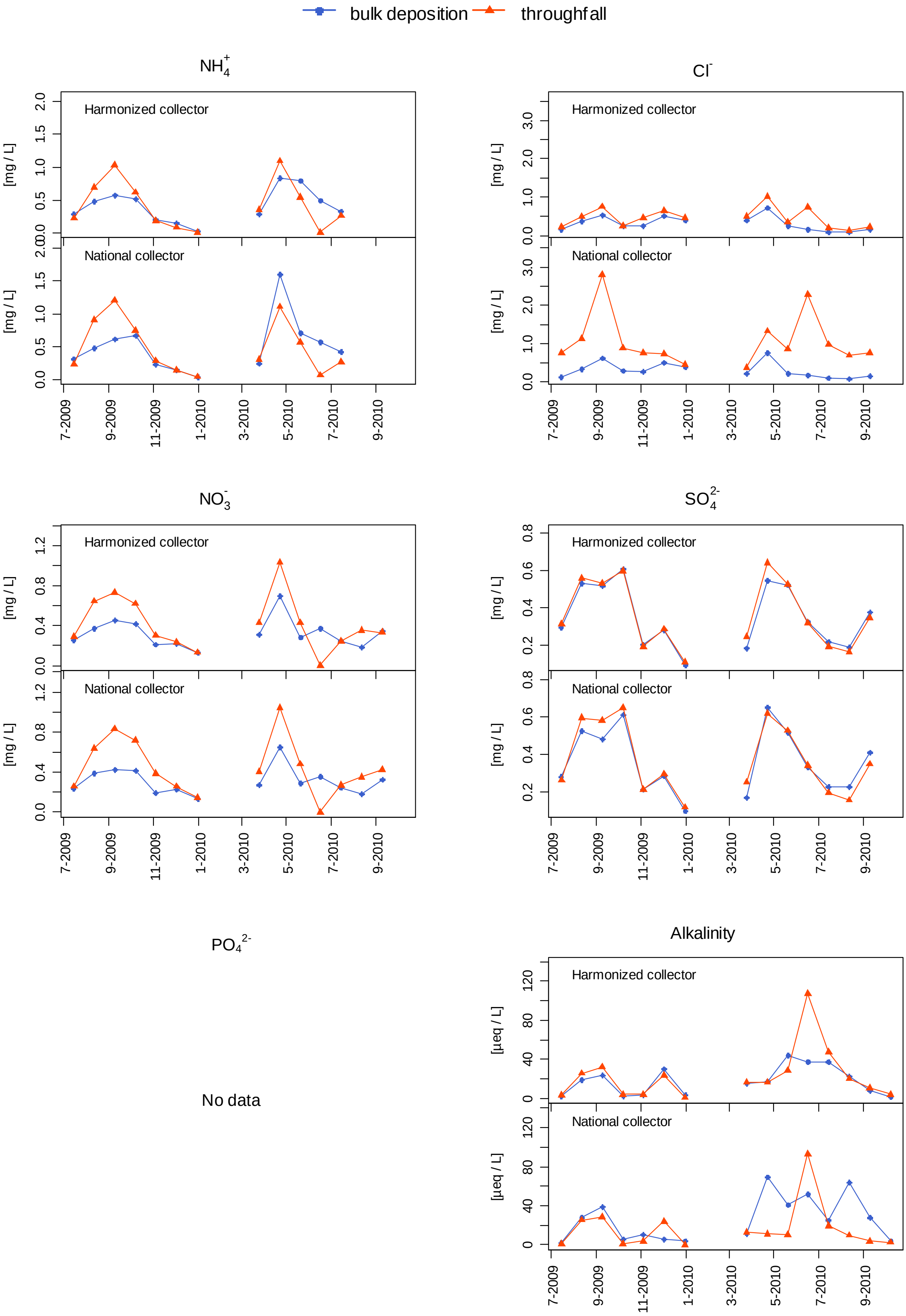
bulk deposition
throughfall
pH
Conductivity
K+
Ca2+
Mg2+
Na+
Harmonized collector
National collector
[µS/cm]
[mg / L]
7-2009
9-2009
11-2009
1-2010
3-2010
5-2010
7-2010
9-2010


bulk deposition
throughfall
NH4+
Cl-
NO3-
SO4 2-
PO4 2-
Alkalinity
Harmonized collector
National collector
[mg / L]
[μeq / L]
No data
7-2009
9-2009
11-2009
1-2010
3-2010
5-2010
7-2010
9-2010

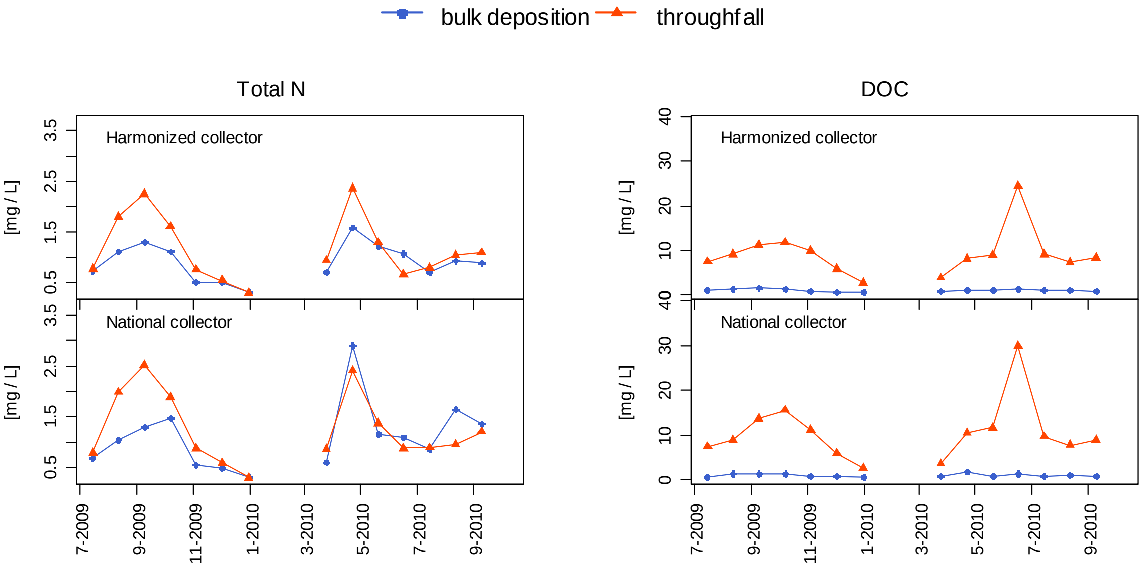

bulk deposition
throughfall
Total N
DOC
Harmonized collector
National collector
[mg / L]
7-2009
9-2009
11-2009
1-2010
3-2010
5-2010
7-2010
9-2010

22


bulk deposition
throughfall
pH
Conductivity
K+
Ca2+
Mg2+
Na+
Harmonized collector
National collector
[µS/cm]
[mg / L]
7-2009
9-2009
11-2009
1-2010
3-2010
5-2010
7-2010
9-2010

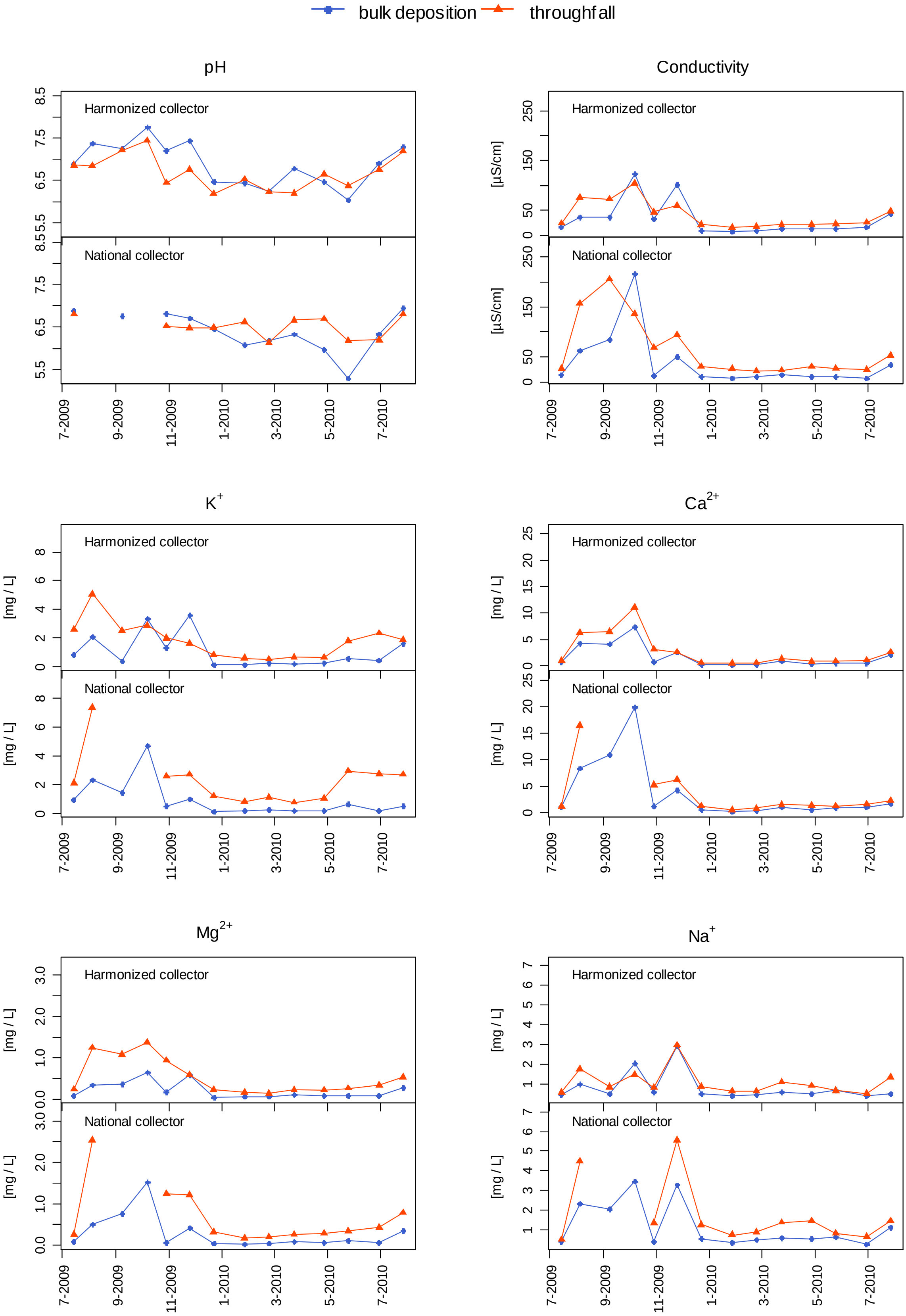


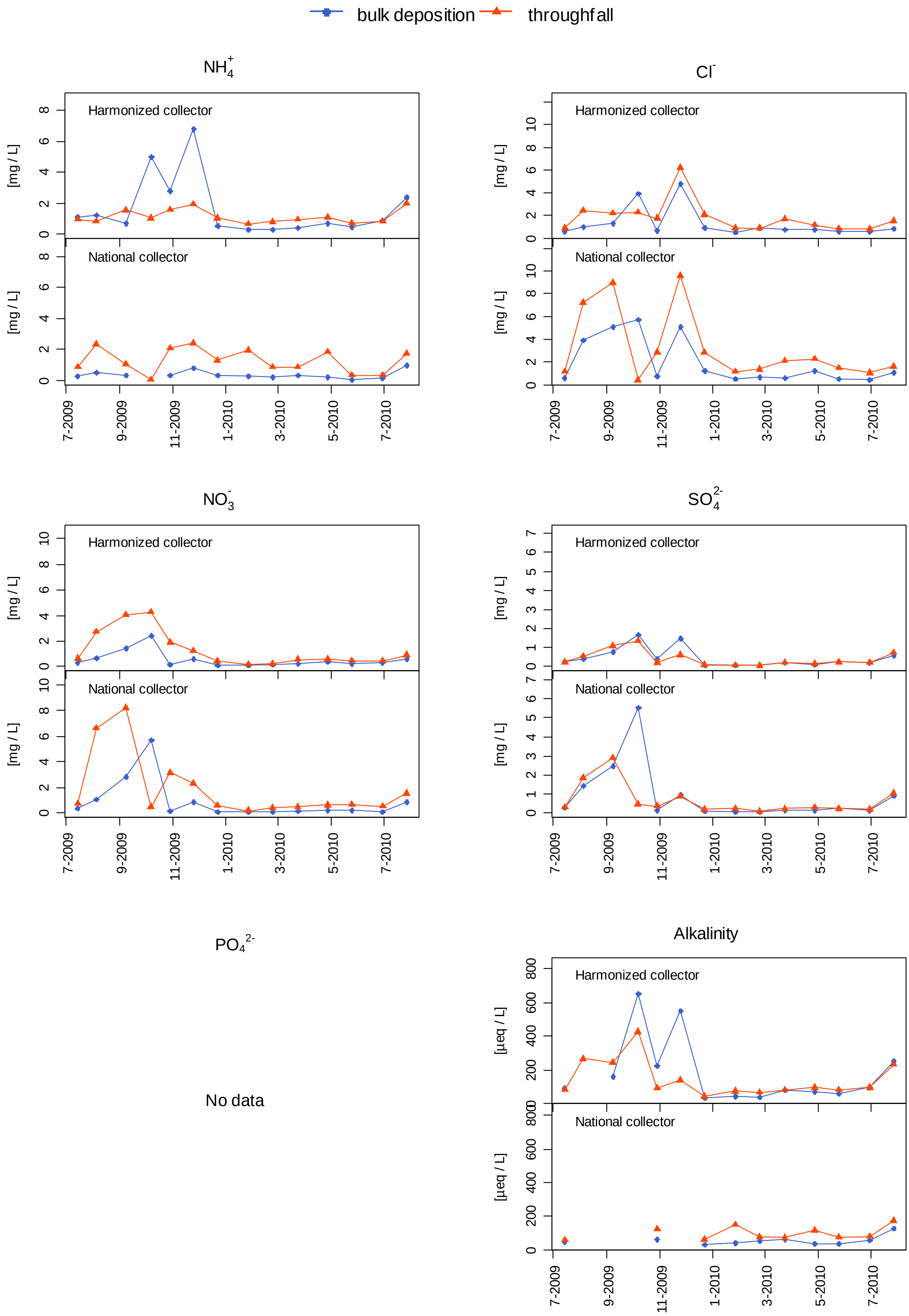
bulk deposition
throughfall
NH4+
Cl-
NO3-
SO4 2-
PO4 2-
Alkalinity
Harmonized collector
National collector
[mg / L]
[µeq / L]
No data
7-2009
9-2009
11-2009
1-2010
3-2010
5-2010
7-2010
9-2010



bulk deposition
throughfall
Total N
DOC
Harmonized collector
National collector
[mg / L]
0.5
1.5
2.5
3.5
0
10
20
30
40
7-2009
9-2009
11-2009
1-2010
3-2010
5-2010
7-2010
9-2010

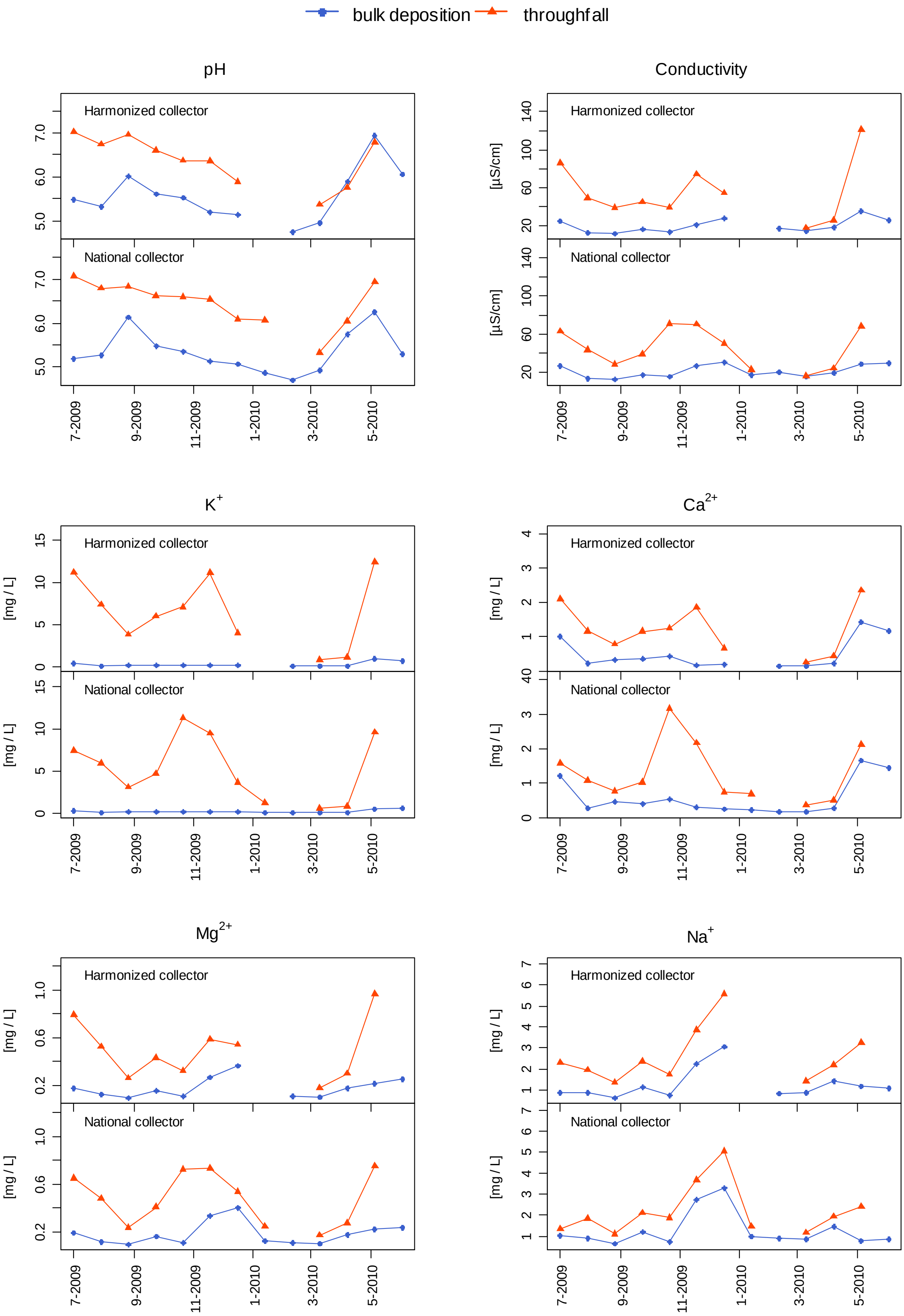
23

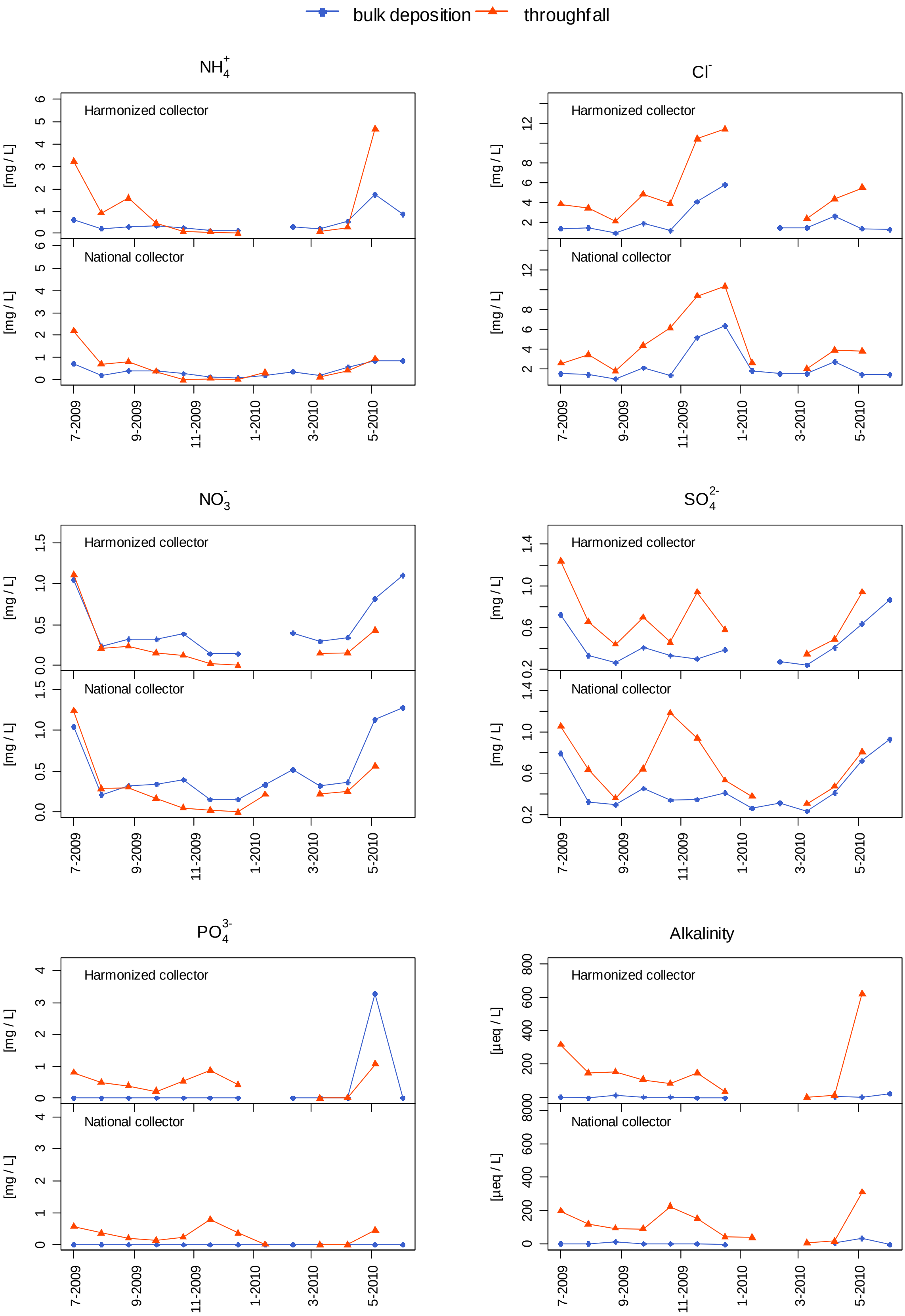

bulk deposition
throughfall
pH
Conductivity
K+
Ca2+
Mg2+
Na+
Harmonized collector
National collector
[µS/cm]
[mg / L]
7-2009
9-2009
11-2009
1-2010
3-2010
5-2010
7-2010

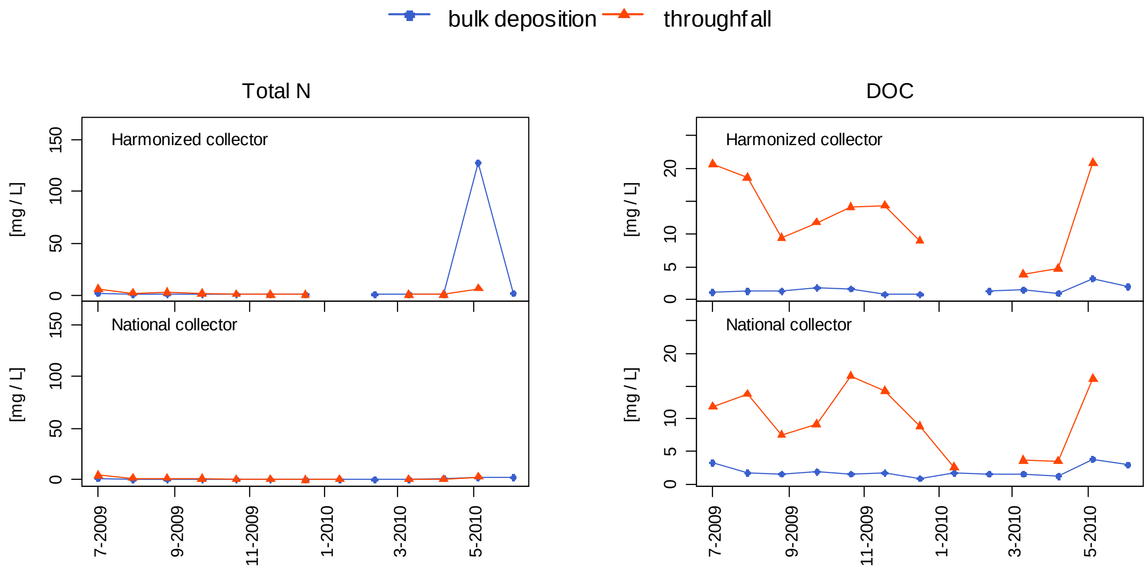

bulk deposition
throughfall
NH4+
Cl-
NO3-
SO4 2-
PO4 2-
Alkalinity
Harmonized collector
National collector
[mg / L]
[µeq / L]
No data
7-2009
9-2009
11-2009
1-2010
3-2010
5-2010
7-2010

Total N	DOC
No data	No data

26

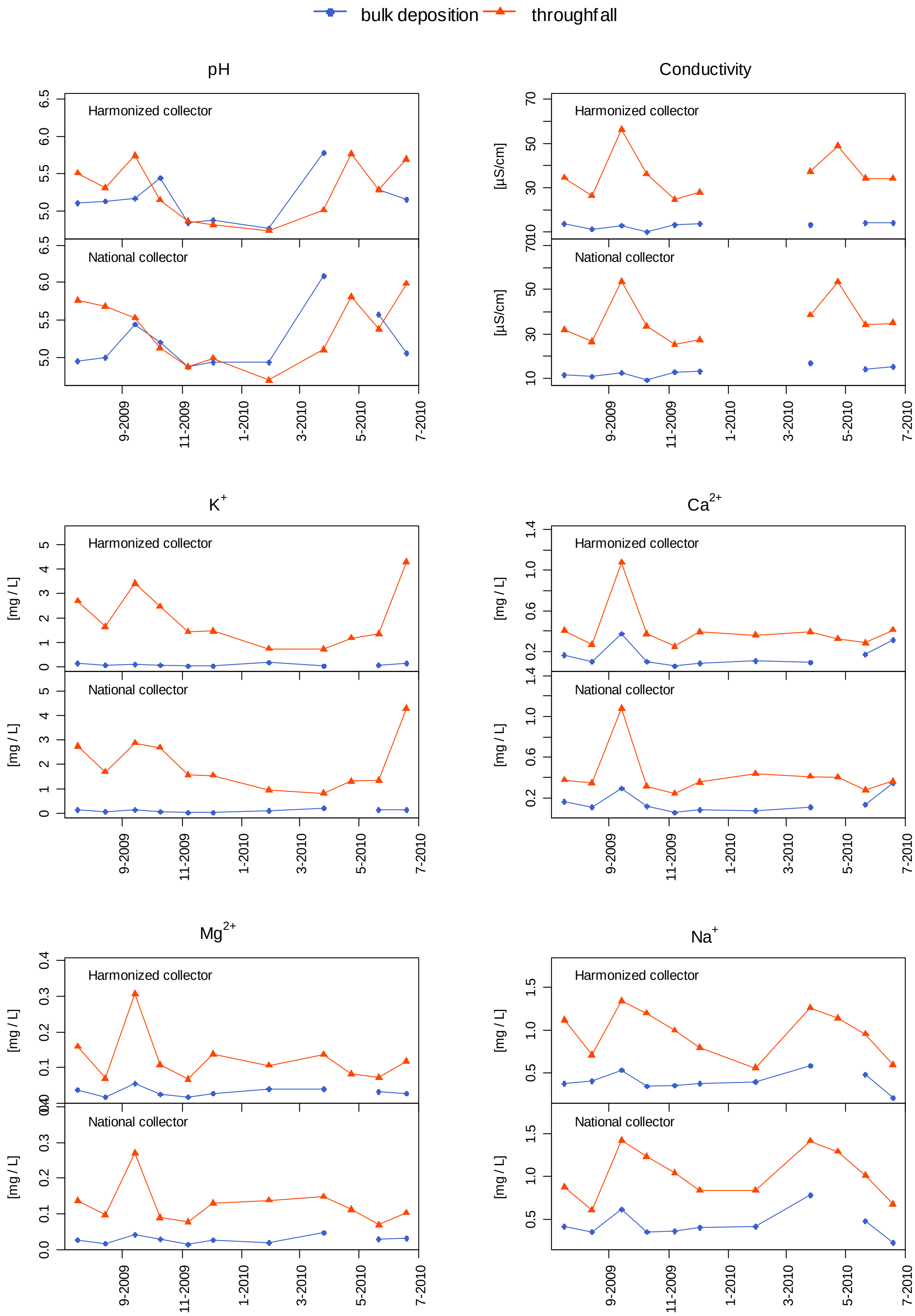

bulk deposition
throughfall
pH
Conductivity
K+
Ca2+
Mg2+
Na+
Harmonized collector
National collector
[µS/cm]
[mg / L]
7-2009
9-2009
11-2009
1-2010
3-2010
5-2010

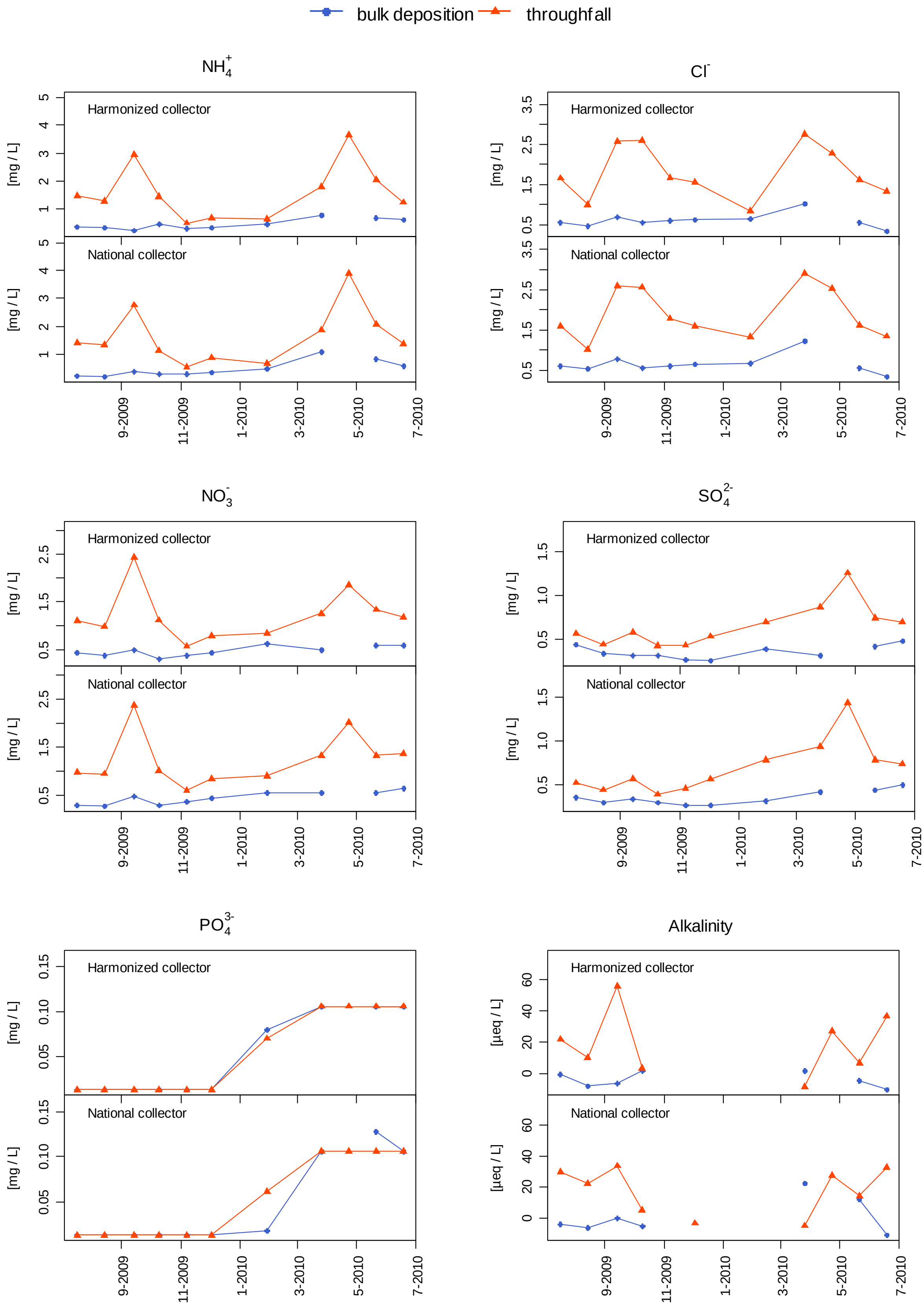

bulk deposition
throughfall
NH4+
Cl-
NO3-
SO4 2-
PO4 3-
Alkalinity
Harmonized collector
National collector
[mg / L]
[µeq / L]
7-2009
9-2009
11-2009
1-2010
3-2010
5-2010

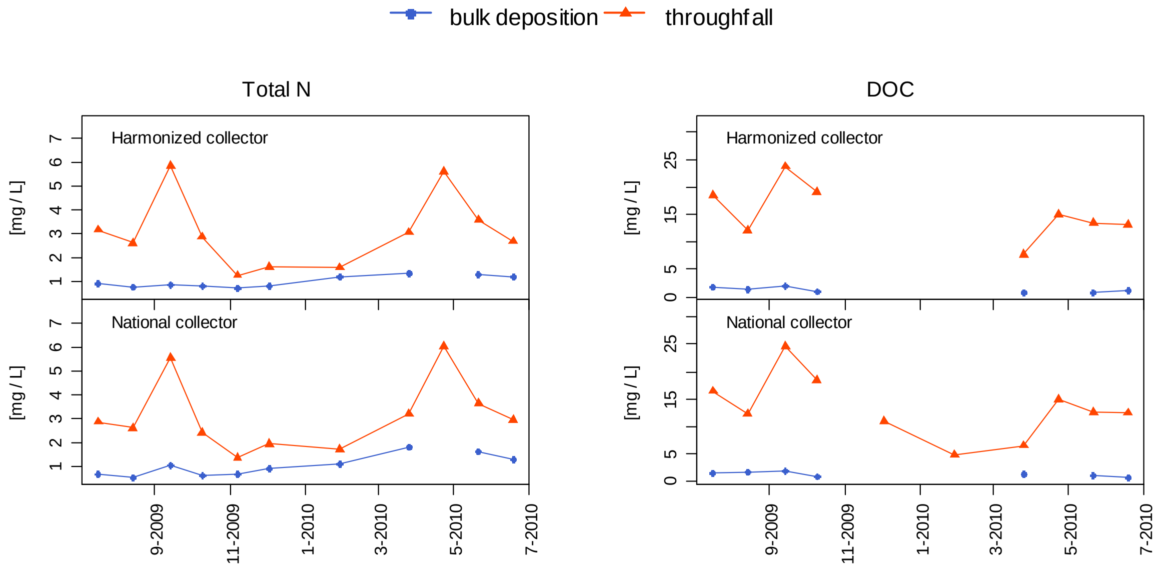


bulk deposition
throughfall
Total N
DOC
Harmonized collector
National collector
[mg / L]
0
50
100
150
5
10
20
7-2009
9-2009
11-2009
1-2010
3-2010
5-2010

30

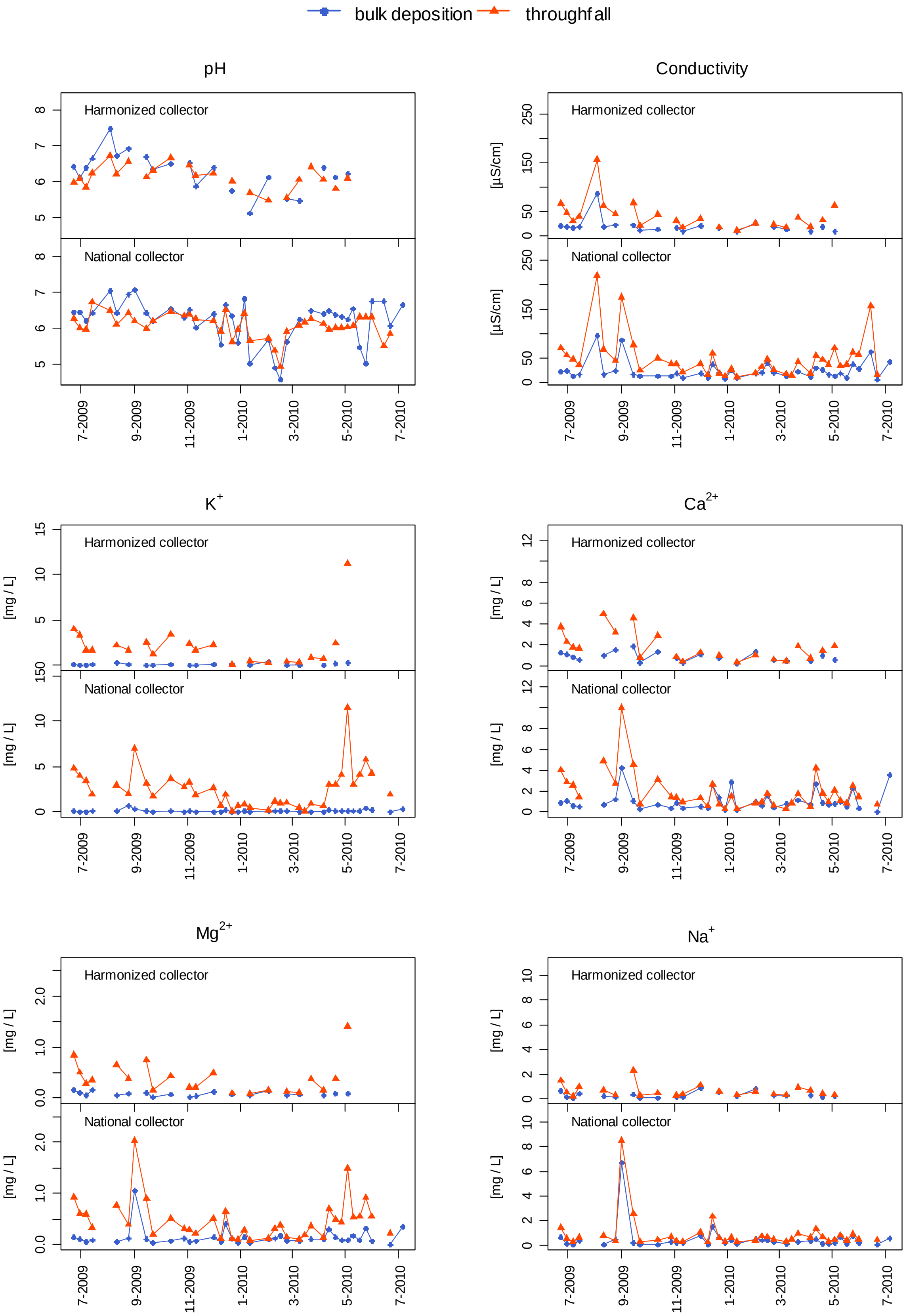

bulk deposition
throughfall
pH
Conductivity
K+
Ca2+
Mg2+
Na+
Harmonized collector
National collector
[µS/cm]
[mg / L]
9-2009
11-2009
1-2010
3-2010
5-2010
7-2010

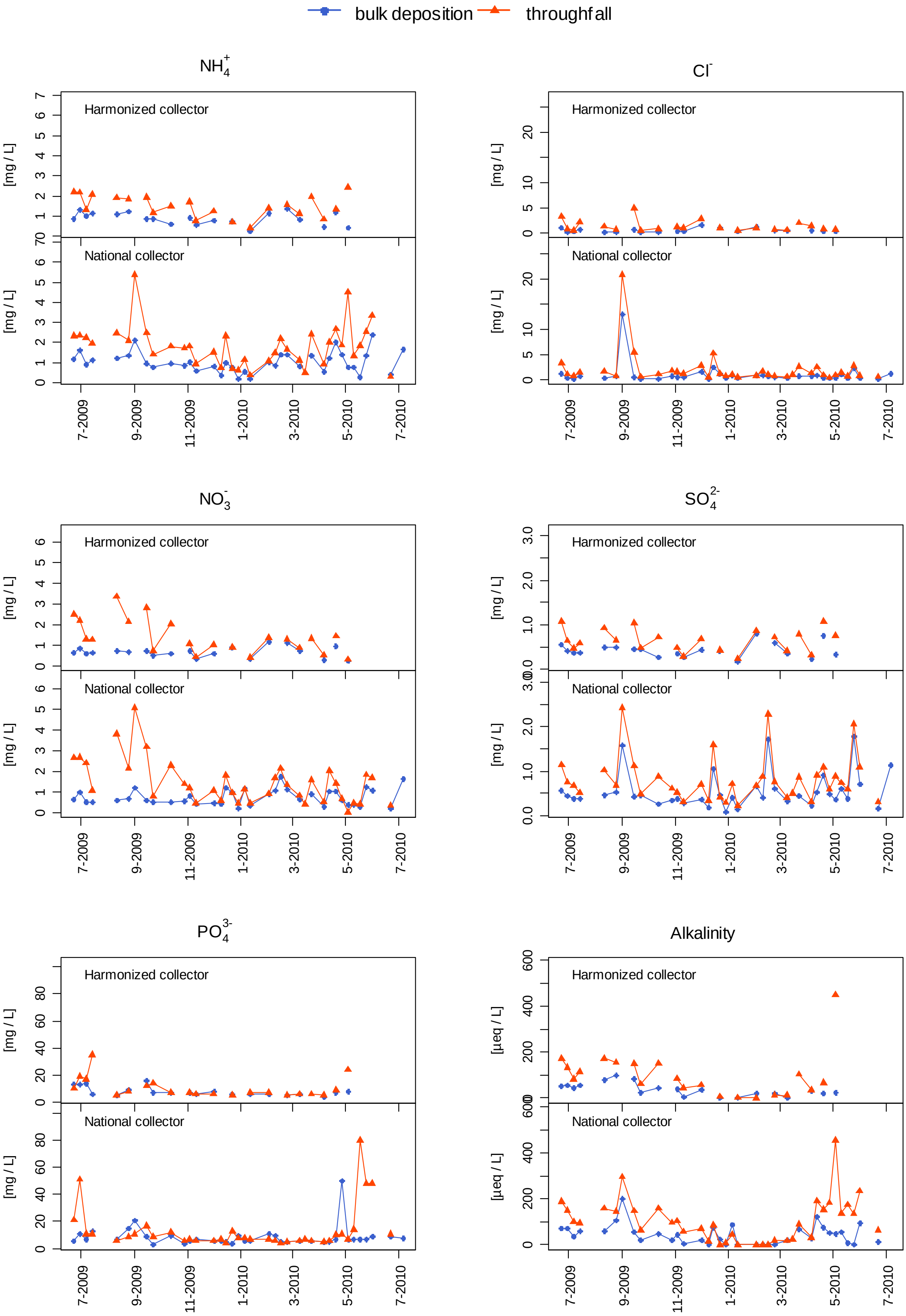

bulk deposition
throughfall
NH4+
Cl-
NO3-
SO42-
PO43-
Alkalinity
Harmonized collector
National collector
[mg / L]
[µeq / L]
9-2009
11-2009
1-2010
3-2010
5-2010
7-2010

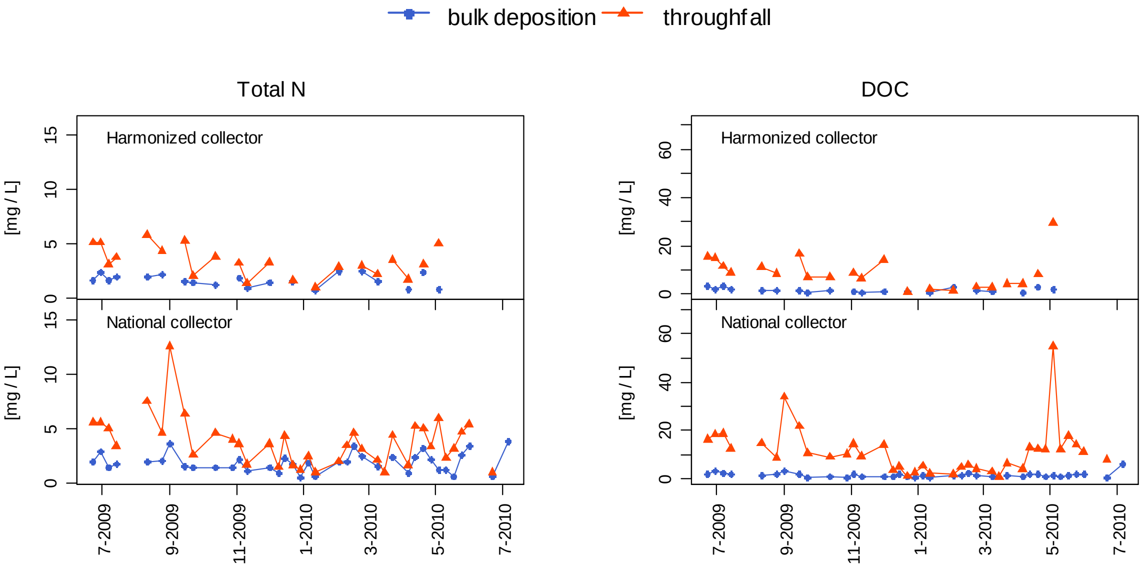


bulk deposition
throughfall
Total N
DOC
Harmonized collector
National collector
Harmonized collector
National collector
[mg / L]
9-2009
11-2009
1-2010
3-2010
5-2010
7-2010

40

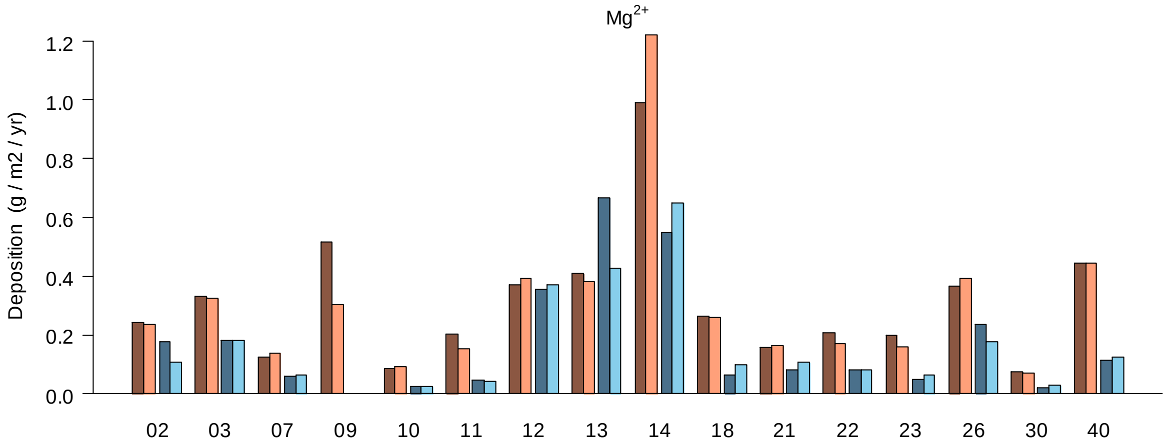

bulk deposition
throughfall
pH
Conductivity
K^+
Ca^{2+}
Mg^{2+}
Na^+
Harmonized collector
National collector
[µS/cm]
[mg / L]
7-2009
9-2009
11-2009
1-2010
3-2010
5-2010
7-2010

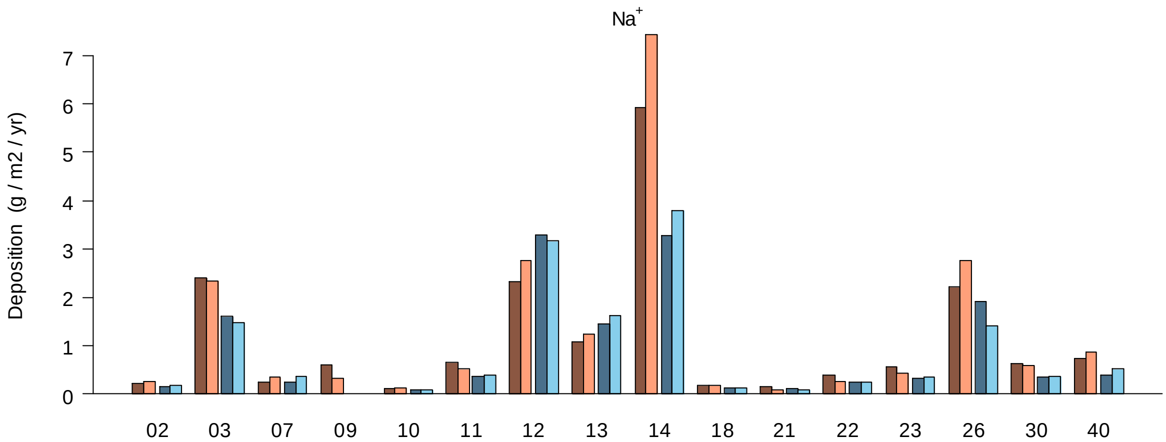

bulk deposition
throughfall
NH4+
Cl-
NO3-
SO4 2-
PO4 3-
Alkalinity
Harmonized collector
National collector
[mg / L]
[µeq / L]
7-2009
9-2009
11-2009
1-2010
3-2010
5-2010
7-2010

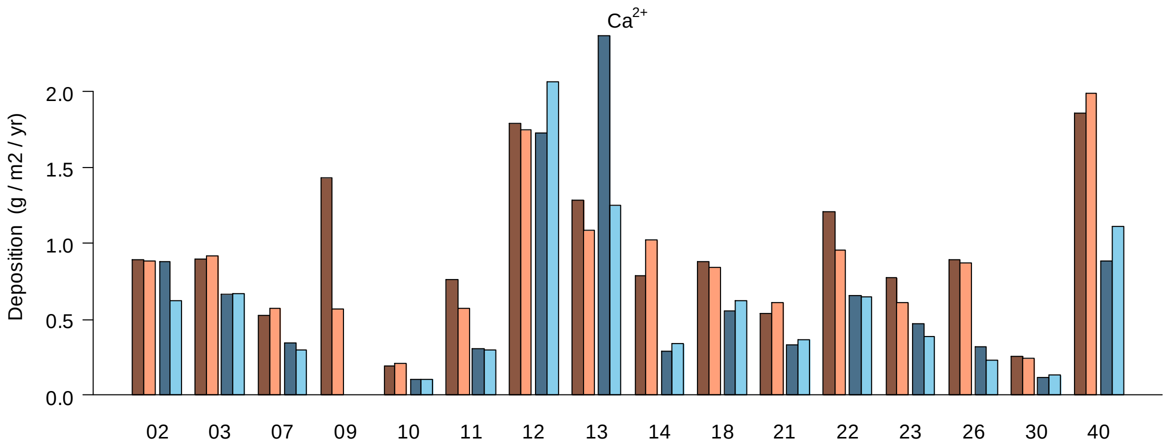

bulk deposition
throughfall
Total N
DOC
Harmonized collector
National collector
[mg / L]
0
5
10
15
20
40
60
7-2009
9-2009
11-2009
1-2010
3-2010
5-2010
7-2010

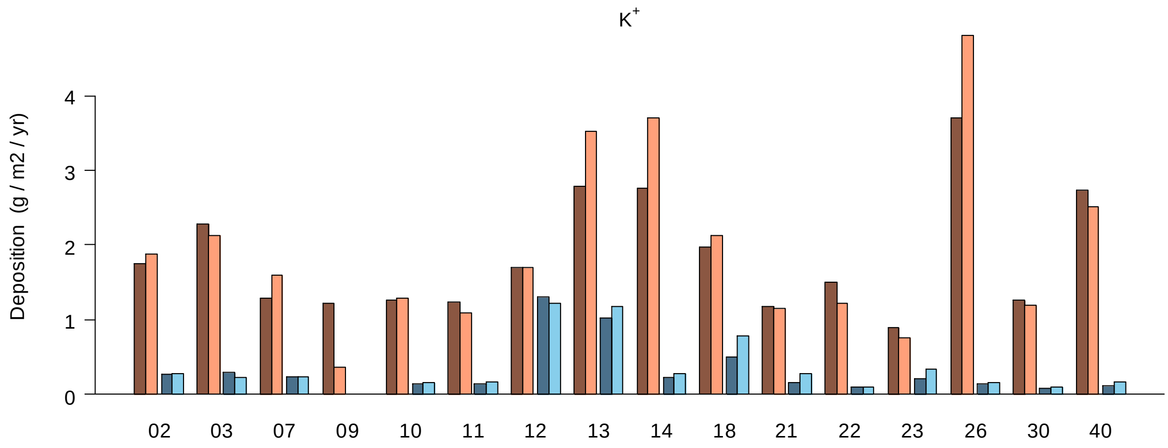
Annex 10: Deposition, extrapolated per 1 year period

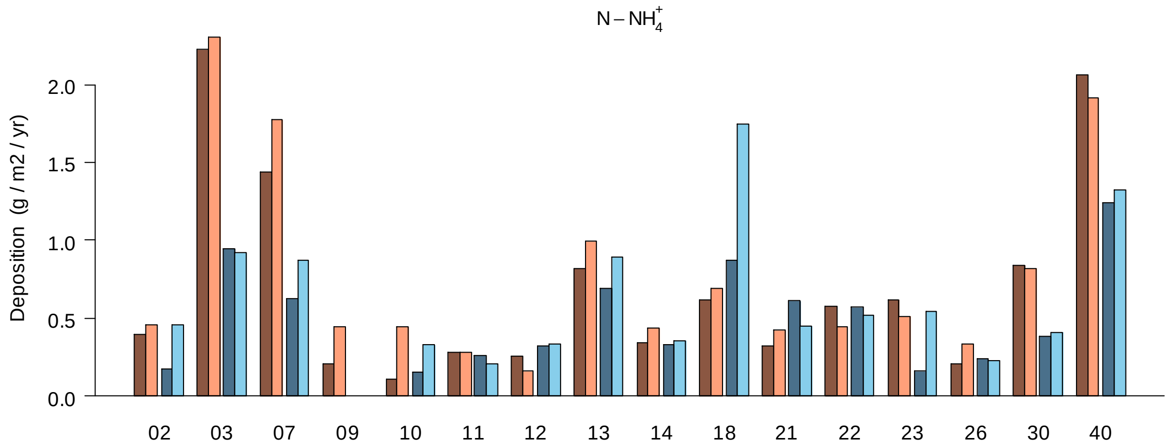
Legend, valid for all figures in this annex:

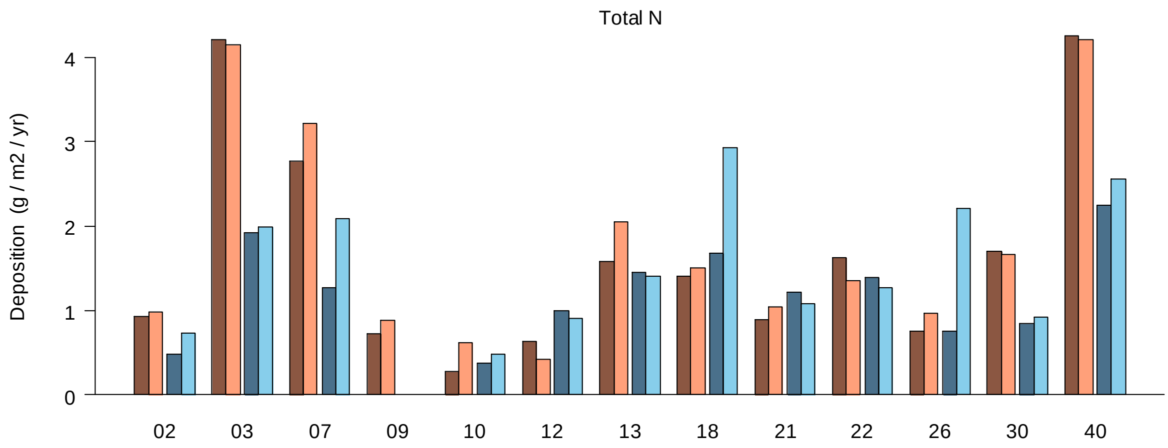


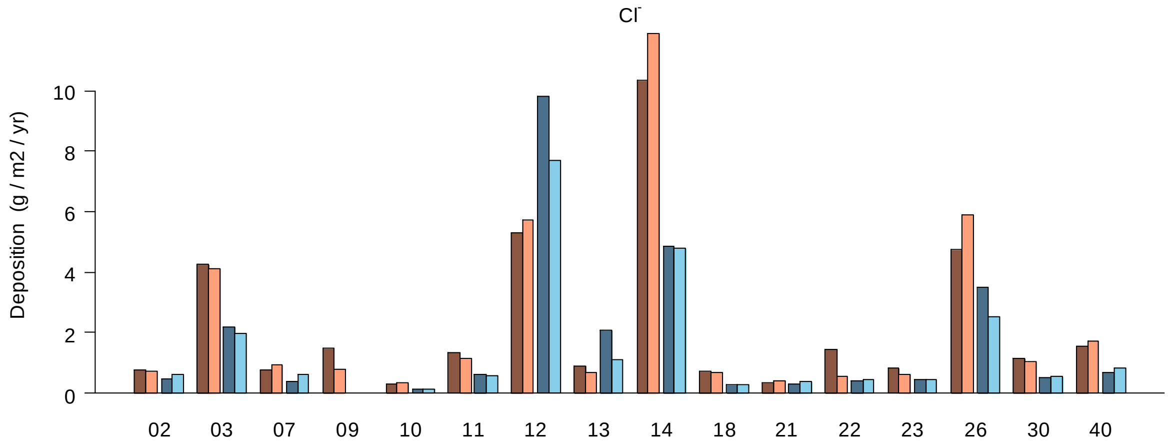


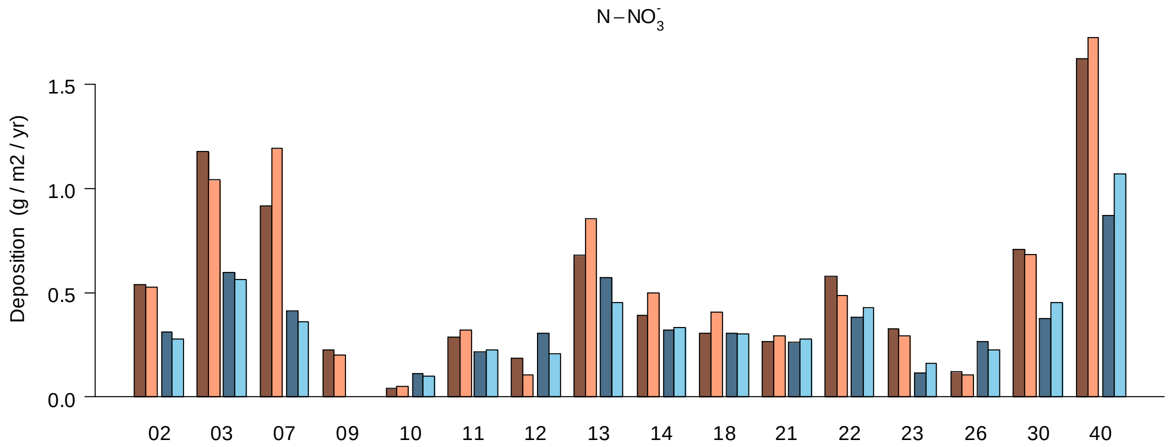


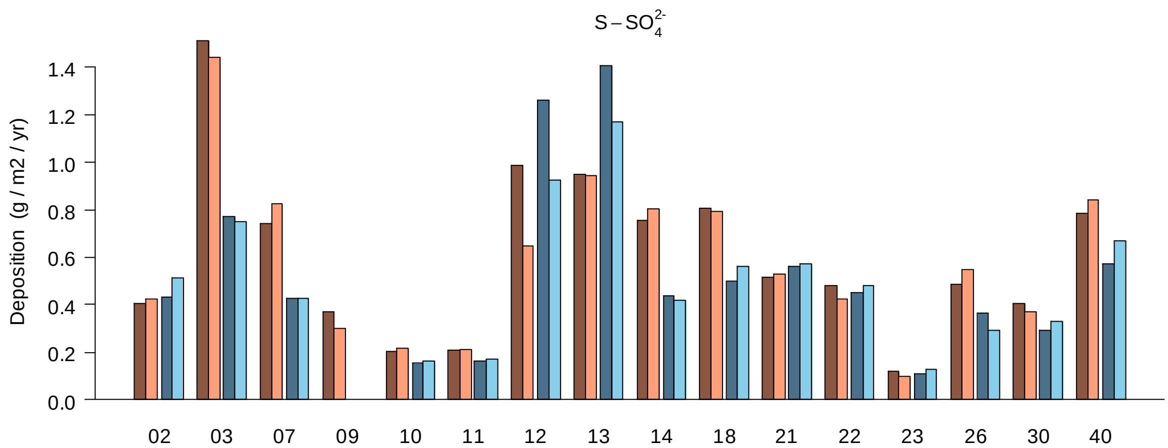

K^+
Deposition (g / m2 / yr)
0
1
2
3
4
02
03
07
09
10
11
12
13
14
18
21
22
23
26
30
40


$N-NH_4^+$
Deposition (g / m2 / yr)
0.0
0.5
1.0
1.5
2.0
02
03
07
09
10
11
12
13
14
18
21
22
23
26
30
40


Total N
Deposition (g / m2 / yr)
0
1
2
3
4
02
03
07
09
10
12
13
18
21
22
26
30
40


Cl^-
Deposition (g / m2 / yr)
0
2
4
6
8
10
02 03 07 09 10 11 12 13 14 18 21 22 23 26 30 40

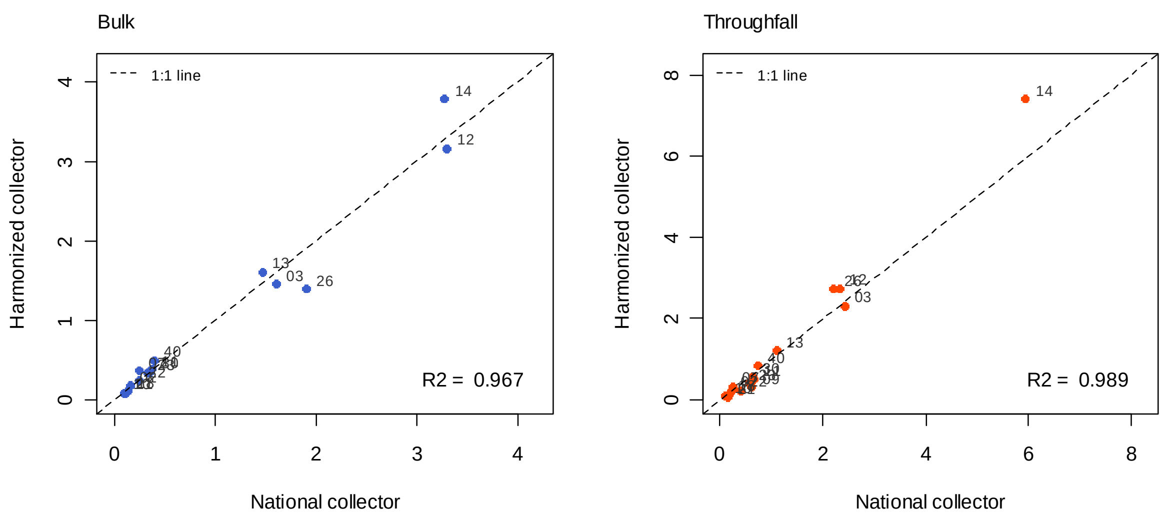

$N-NO_3^-$
Deposition (g / m2 / yr)
0.0
0.5
1.0
1.5
02 03 07 09 10 11 12 13 14 18 21 22 23 26 30 40


$S-SO_4^{2-}$
Deposition (g / m2 / yr)
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
02 03 07 09 10 11 12 13 14 18 21 22 23 26 30 40

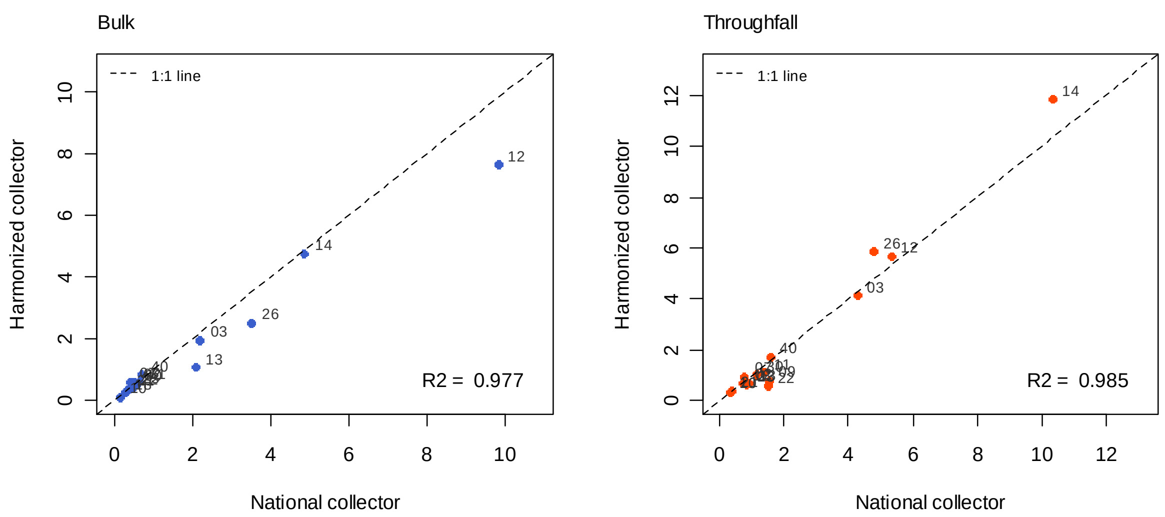
Annex 11: Combined plots of total deposition of different chemical parameters

In the next figures combined plots are presented for all beneficiaries showing the agreement in total deposition (in g m^{-2} $year^{-1}$) of different chemical parameters between national and harmonized collectors. Data labels represent beneficiary codes. R^2 values are also presented.

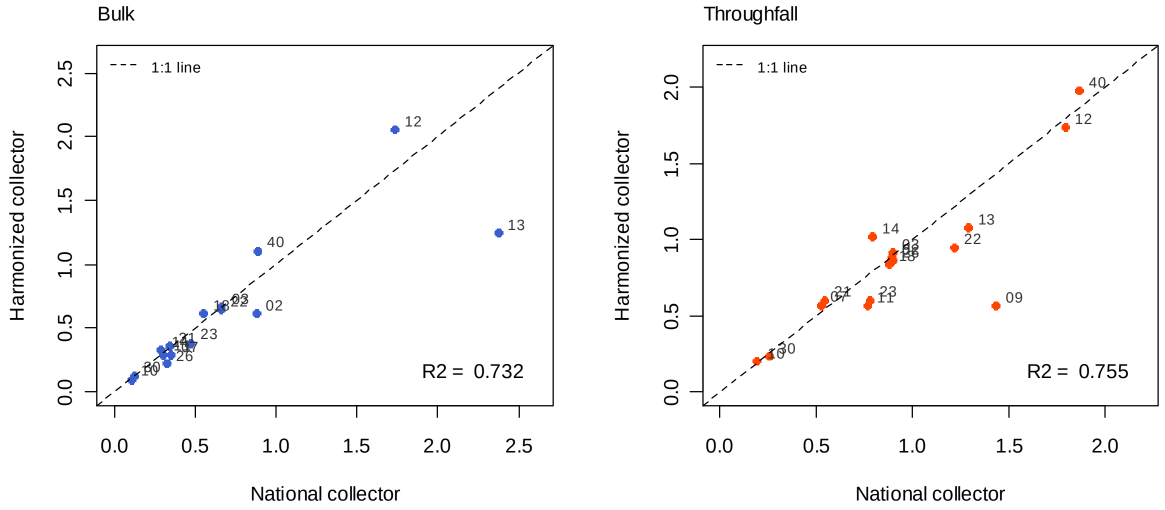
Na^+



Cl^-

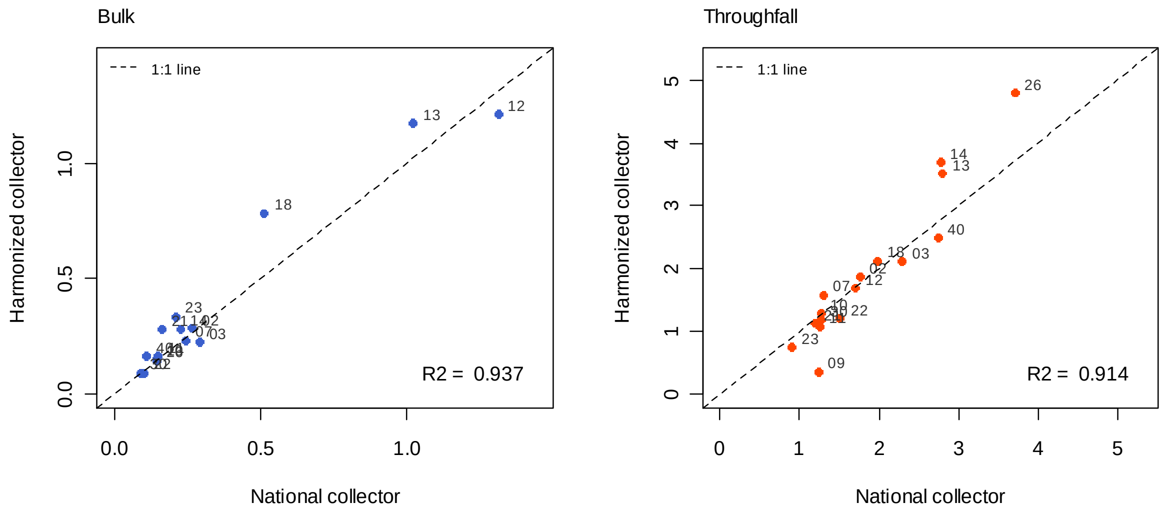


Ca^{2+}



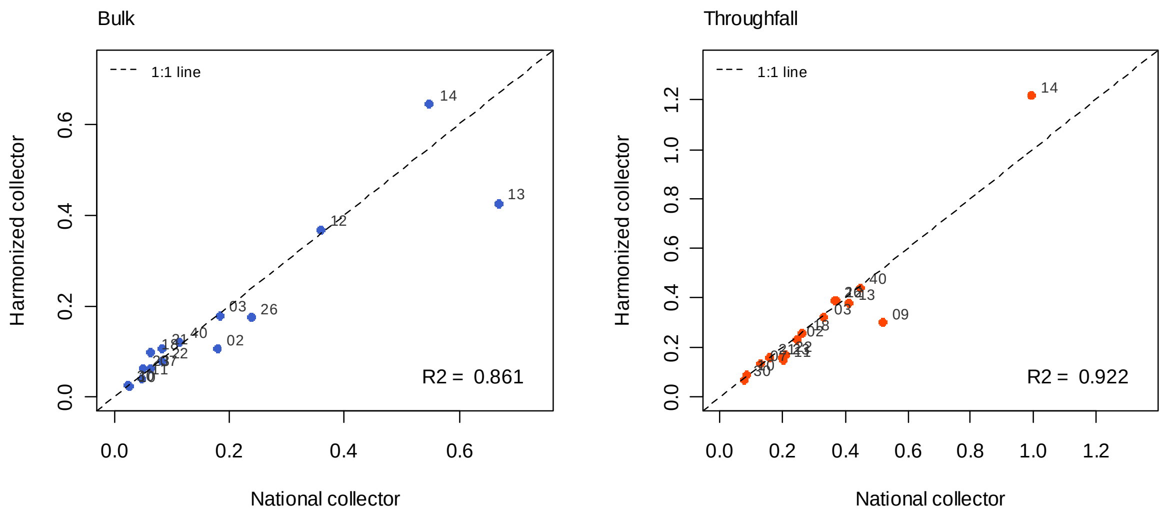
Bulk
1:1 line
Harmonized collector
National collector
R2 = 0.732
Throughfall
1:1 line
Harmonized collector
National collector
R2 = 0.755

K^{+}

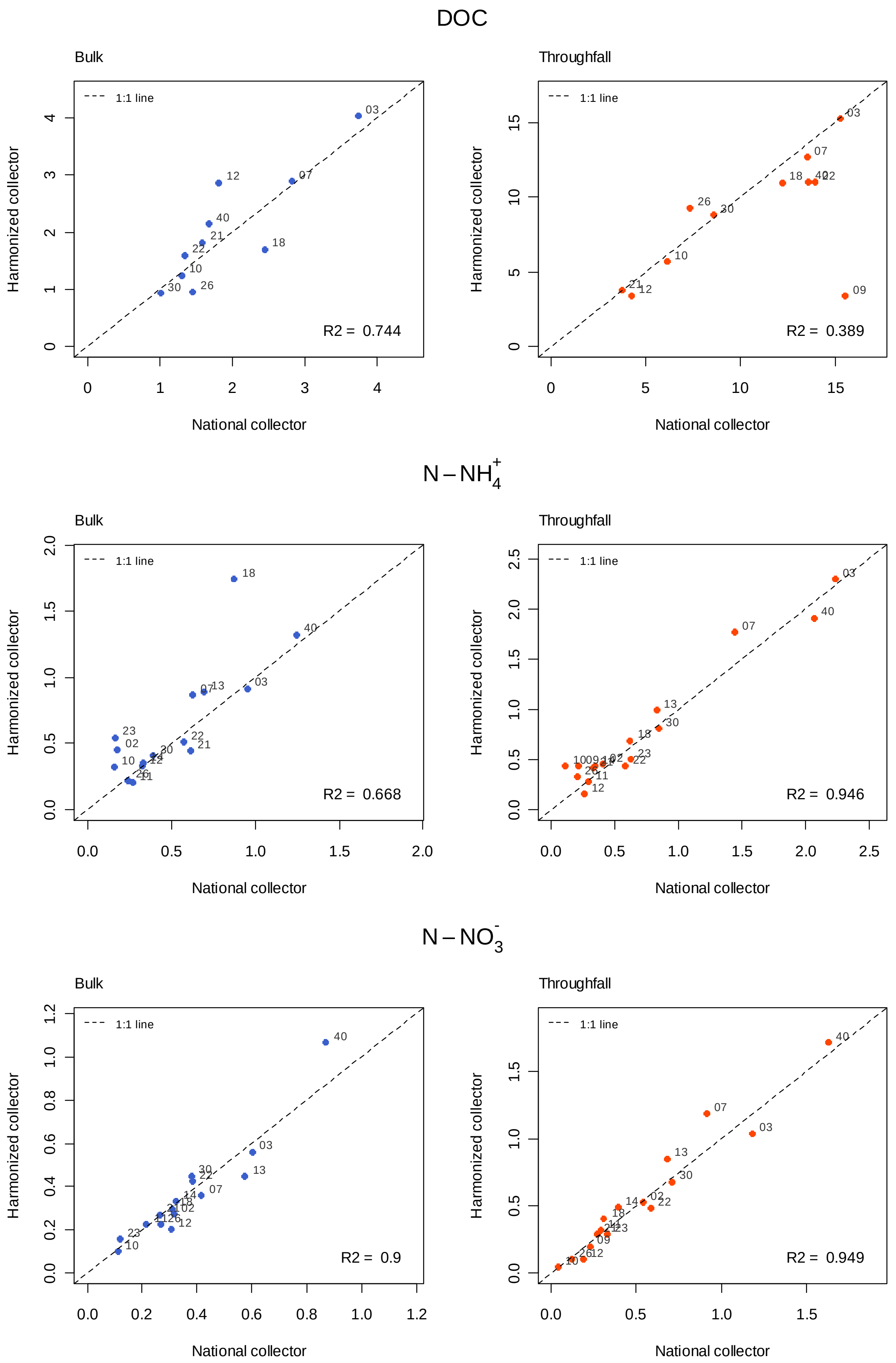


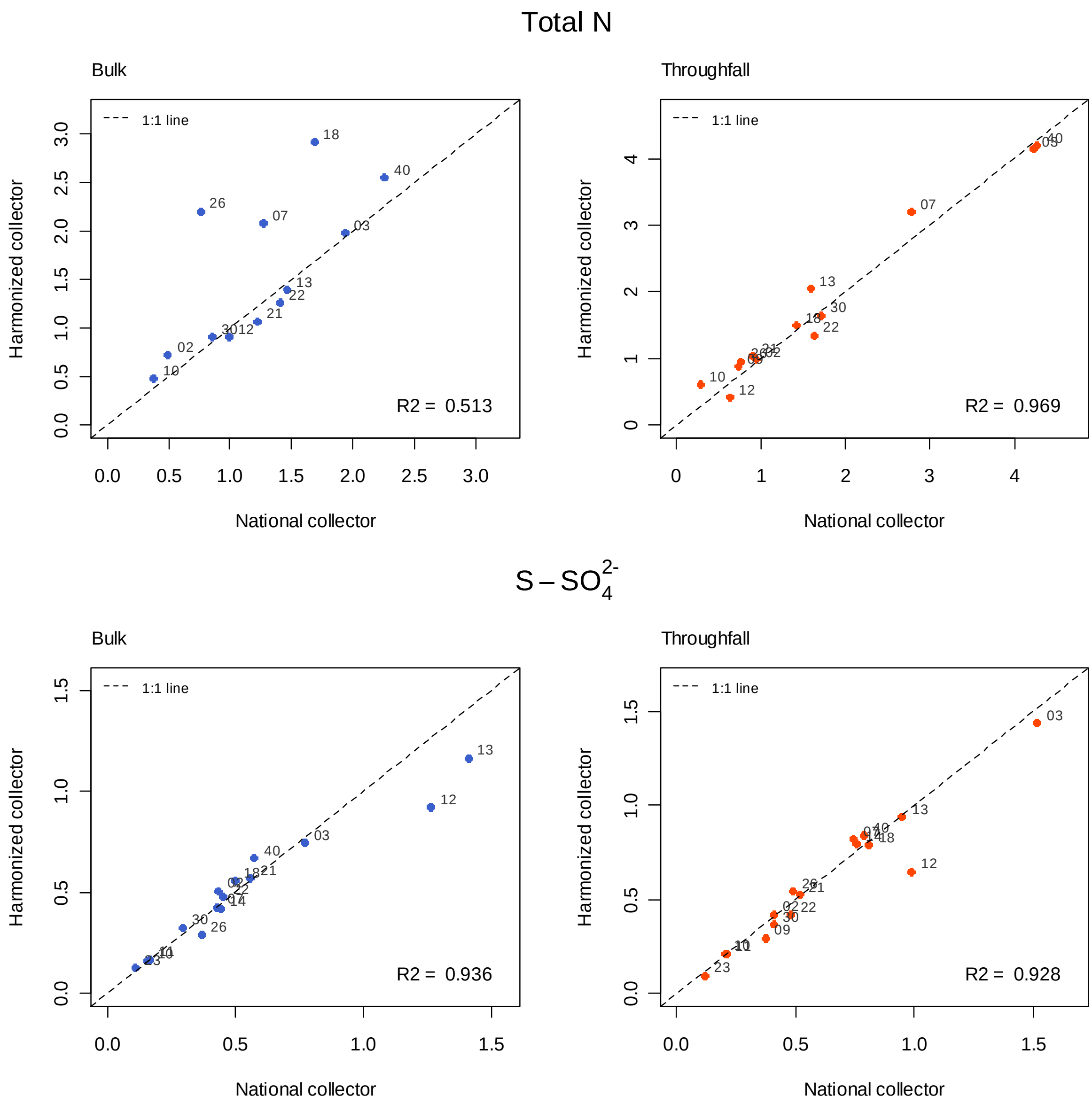
Bulk
1:1 line
Harmonized collector
National collector
R2 = 0.937
Throughfall
1:1 line
Harmonized collector
National collector
R2 = 0.914

Mg^{2+}



Bulk
1:1 line
Harmonized collector
National collector
R2 = 0.861
Throughfall
1:1 line
Harmonized collector
National collector
R2 = 0.922


DOC
Bulk
Throughfall
1:1 line
R2 = 0.744
R2 = 0.389
N – NH$_4^+$
Bulk
Throughfall
1:1 line
R2 = 0.668
R2 = 0.946
N – NO$_3^-$
Bulk
Throughfall
1:1 line
R2 = 0.9
R2 = 0.949
Harmonized collector
National collector


Total N
Bulk
Throughfall
1:1 line
Harmonized collector
National collector
R2 = 0.513
R2 = 0.969
$S-SO_4^{2-}$
Bulk
Throughfall
1:1 line
Harmonized collector
National collector
R2 = 0.936
R2 = 0.928