DISDROMETER RD-80

User Guide for DISDRODATA 2.0

Data Acquisition on Personal Computer for Disdrometer RD-80

for Microsoft WINDOWS 2000, XP, Vista

March 18, 2009

DISTROMET LTD **www.distromet.com**

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1. INTRODUCTION

The DISDRODATA software consists of two program modules available after installation:

- **DATA LOGGING** (see Chapt. 2)
  enabling users of RD-80 or RD-69 disdrometers to record drop size measurements with a personal computer. Following, RD-80 stands for both RD-80 and the earlier RD-69 connected to ADA-90.
- **DATA PROCESSING** (see Chapt. 3)
  displays recorded data and helps to locate and extract relevant rain data for further analysis. Parameters and distributions are calculated for a selectable time interval. All results can be saved on files and displayed.

  Both modules can be run in a Demo Mode with simulated drop data and without having a RD-80 hardware connected to the PC.

1.1 System requirements

Desktop or Notebook with:

- Windows 2000, XP, or Vista, no high performance system required
- Free space on disc: min 200 MB
- Display settings: 1024 x 768 pixels or better
- Serial Port (RS-232) or USB-to-RS232 converter (e.g. ATEN UC-232A)
- UPS, recommended
- MS EXCEL Spreadsheet, may be useful to examine data

1.2 Installation of DISDRODATA from downloaded files

In the Internet a more current version of Disdrodata may be available for download. Go to http://www.distromet.com and follow the instructions.

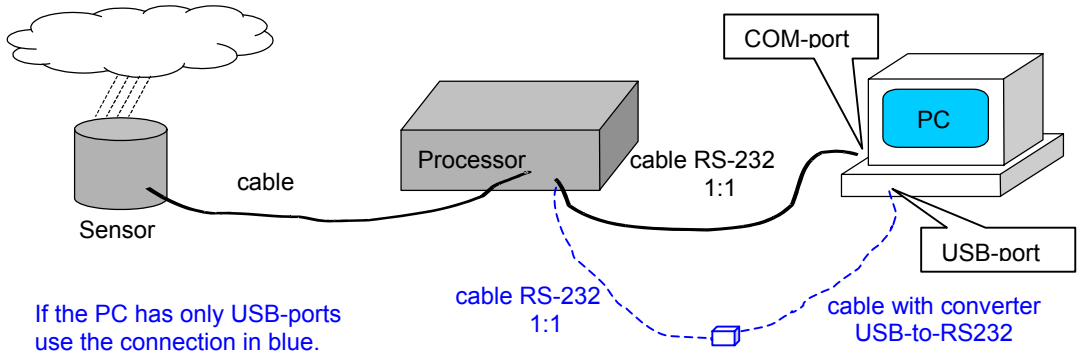
The DISDRODATA program executes based on the *NI LabVIEW Run-Time Engine 8.2.1* (by National Instruments Corporation) which is installed automatically after installing DISDRODATA.

1.3 Installation of DISDRODATA from CD

1. Insert CD into CD drive
2. Follow instructions on screen
3. alternatively: Double-click the following file to startup installation:
   [CD drive]\Installer\Setup.exe

1.4 How to connect your RD-80

Connect the components according to the following figure:



1.5 Considerations about data integrity

Use DISDRODATA on a PC reserved for data acquisition. Using other software on the same PC during measurements (e.g. for printing or analysing data) is not recommended. The reliability of the data acquisition may be reduced by absorbtion of system resources by other activities or by affecting the stability of the system.

The program acquires rain drop data continuously and writes new data at the end of each sampling interval (e.g.: every minute) to the output file. In addition (optional) a second data file can be produced with redundant data. This helps prevent data loss in case of power failure or permits to transfer data to another computer automatically. See 2.3.2.

Some PCs can be enabled to restart after power failure without user interaction. In this case, the program can be configured to automatically continue with data acquisition. See menu “Settings – configure logging”.

We recommend to use an uninterruptible power supply (UPS) to enhance availability.

Screensavers, power saving or sleeping modes can interrupt proper data acquisition as well. Make sure they don’t become active during measurement.

1.6 Time synchronisation

After you leave your computer on for an extended amount of time, the task bar clock may lose several seconds per day.

It is recommended to activate a daily time synchronisation with an internet time server.

1.7 Limited warranty

DISTROMET LTD warrants that the software product will perform substantially in accordance with the accompanying written materials for a period of 6 months from the date of receipt.

1.8 Limitation of liability

In no event shall DISTROMET LTD or its suppliers be liable for any special, incidental, indirect, or consequential damages whatsoever (including, without limitation, damages for loss of profits, interruptions in business or research, loss of information, or any other pecuniary loss) arising out of the use of or inability to use the software product or the provision of or failure to provide support services.

1.9 Feedback / support

Feedback is always welcome in order to enable us to improve these products according to your needs. Thank you.

Support is available by e-mail: info@distromet.com.

2. The DATA LOGGING Program

2.1 Purpose and main functions

- Start and control of data logging process
- Select time interval for sampling
- Display drop data, number of drops in each class of diameter
- Display overview: Rain Intensity registered within the last 48 hours
- Create output file with rain drop data. (Recorded Data)
- Demo mode with simulated drops. Working without RD-80 equipment connected.

2.2 Drop size classes

According to it's principle of operation the Disdrometer RD-80 measures the size distribution of rain drops falling on the sensitive surface of the sensor. From this it is easy to calculate the actual drop size distribution in a volume of air.

The range of drop diameters that can be measured spans from 0.3 mm to 5 mm. Drops smaller than 0.3 mm cannot be measured due to practical limits of the measuring principle and are usually of minor importance in applications for which the instrument is intended. Drops larger than 5 mm are very rare because of drop break-up due to the instability of large drops.

The Disdrometer RD-80 distinguishes 127 classes of drop diameter.
To reduce the amount of data and to get statistically meaningfull samples, the 127 drop size channels are combined into 20 drop size classes distributed more or less exponentially over the available range of drop diameters. This transformation into 20 classes is performed by the DATA LOGGING program.

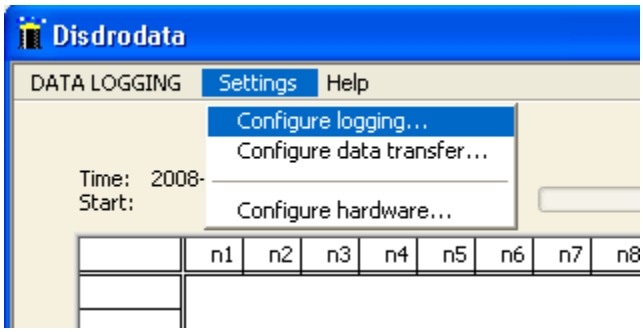
See **Appendix 4.2.**

2.3 How to use DATA LOGGING

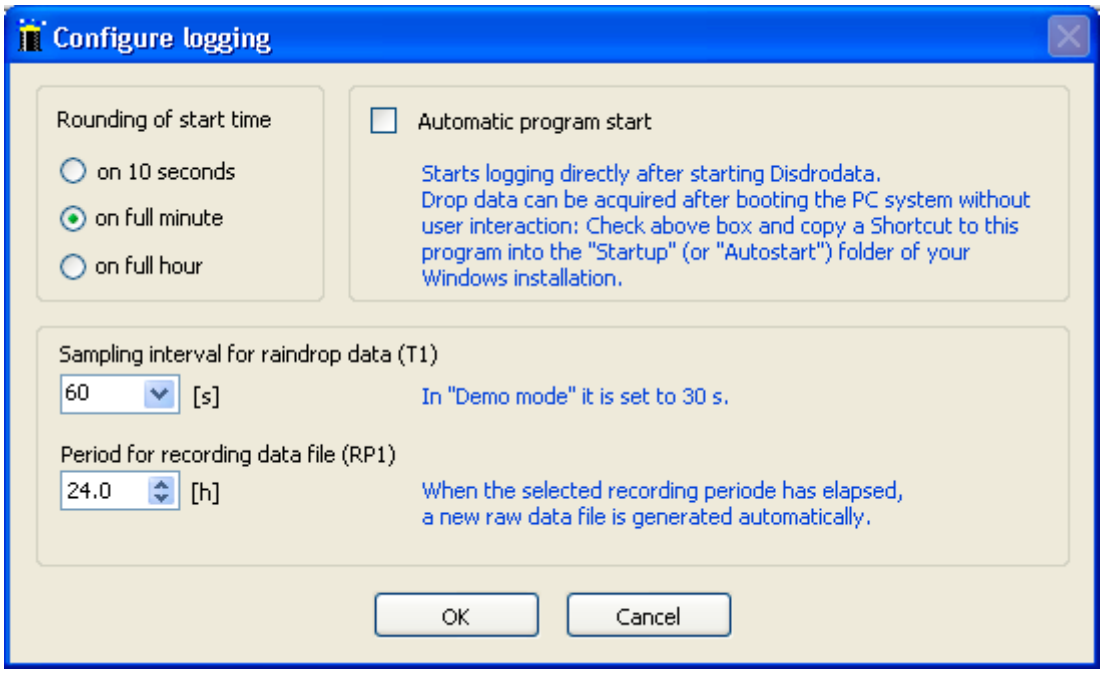
Start DISDRODATA by using the provided link during installation or by running DISDRODATA.exe

☞ Select DATA LOGGING using the first pull down menu.
The following window must be present.

☞ Before starting the logging process, select appropriate values in the pulldown menu “Settings” in order to configure data logging, data transfer and hardware.



2.3.1 Settings - configure logging



☞ select **sampling interval**

If the sampling interval T1 is set to 60 seconds, all drops within 60s will be accumulated in the corresponding drop size class. At the end of each interval, a time stamp and drop data are written in the recording data file. A time stamp marks always the beginning of an interval.

☞ Select **recording period**

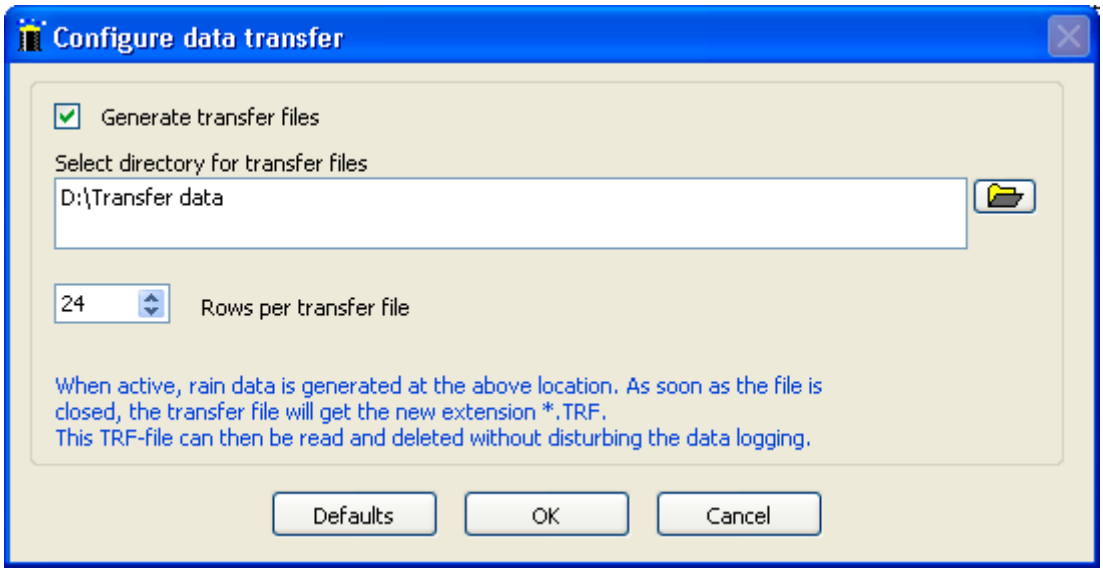
Once the recording period RP1 for the data file has elapsed a new file is generated automatically. Data logging is continuing and there is no loss of data. The file name shows the date and time of creation of the new file.

e.g.

RP1 = 24 h creates data files of one day length (recommended standard)
RP1 = 6 h creates shorter files. Files without rain can be eliminated easily
RP1 = 999 h maximum

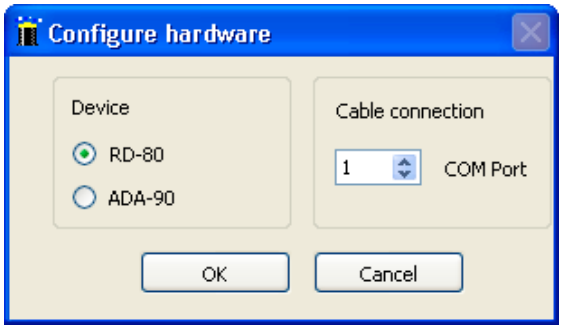
2.3.2 Settings – configure data transfer

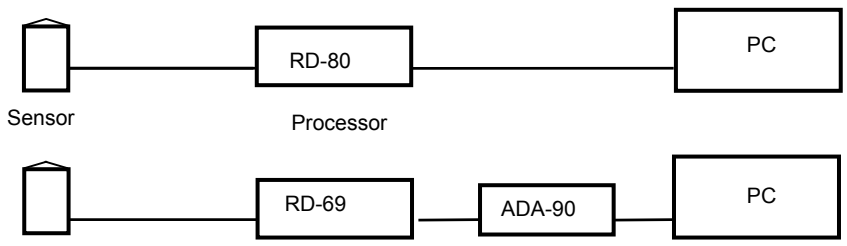
This option generates a second output file with redundant data on a selectable location. This location or directory could also be on a server collecting the data of the Disdrometer. Data files ready for transfer are marked with an extension **.rtf** and can be read periodically (and deleted afterwards) by a customer's program. Create a directory in your file structure to receive these redundant data files.



2.3.3 Settings – configure hardware

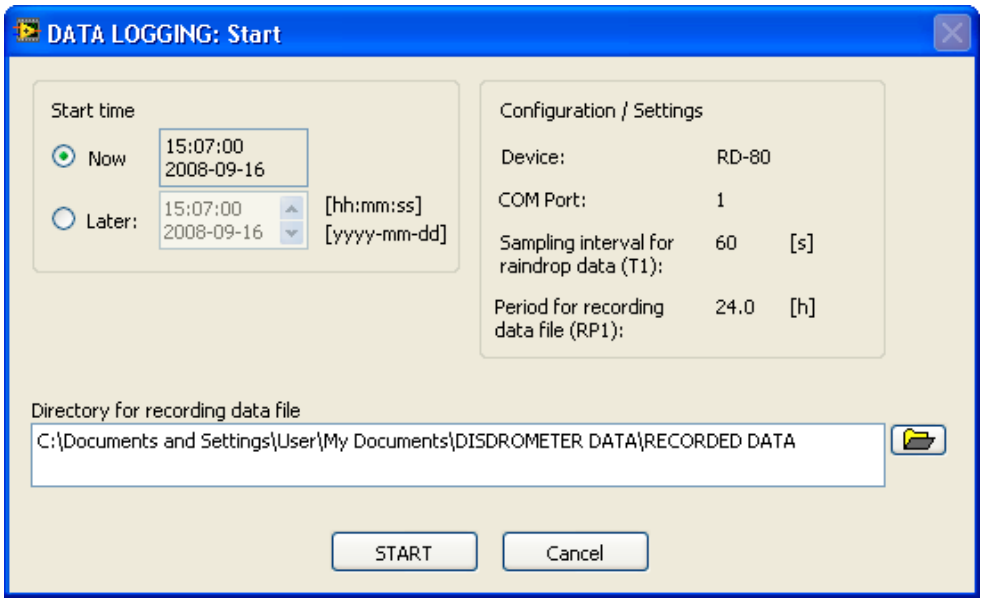
- ☞ Set the device: RD-80 or ADA-90 for older models (RD-69 combined with ADA-90)
- ☞ Select a free COM port for your RS-232 data transfer from the Distrometer.





2.3.4 Start logging

Use the pull down menu DATA LOGGING, select *start logging…*

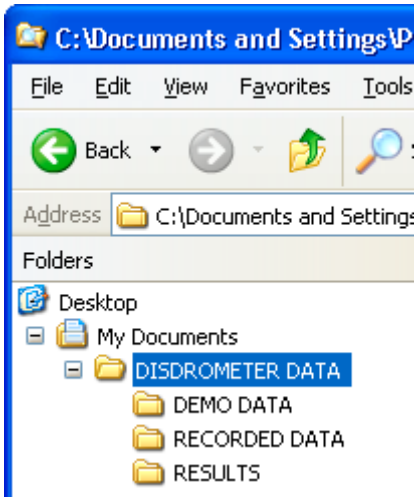


- ☞ Select **Start time**: either immediately or later at a specified time and
- ☞ select the **directory for the recorded data file.** See remarks below
- ☞ press **START.** The main window will appear and data logging starts.

2.3.4.1 Directory for RECORDED DATA

By default the directory RECORDED DATA is selected. Therefore all data files created during the data logging process will be registered in RECORDED DATA.

Remark on data handling:
In order to facilitate the handling and organisation of collected data and calculated results the following structure of directories is recommended. Therefore such directories have been created automatically during program installation and first start:

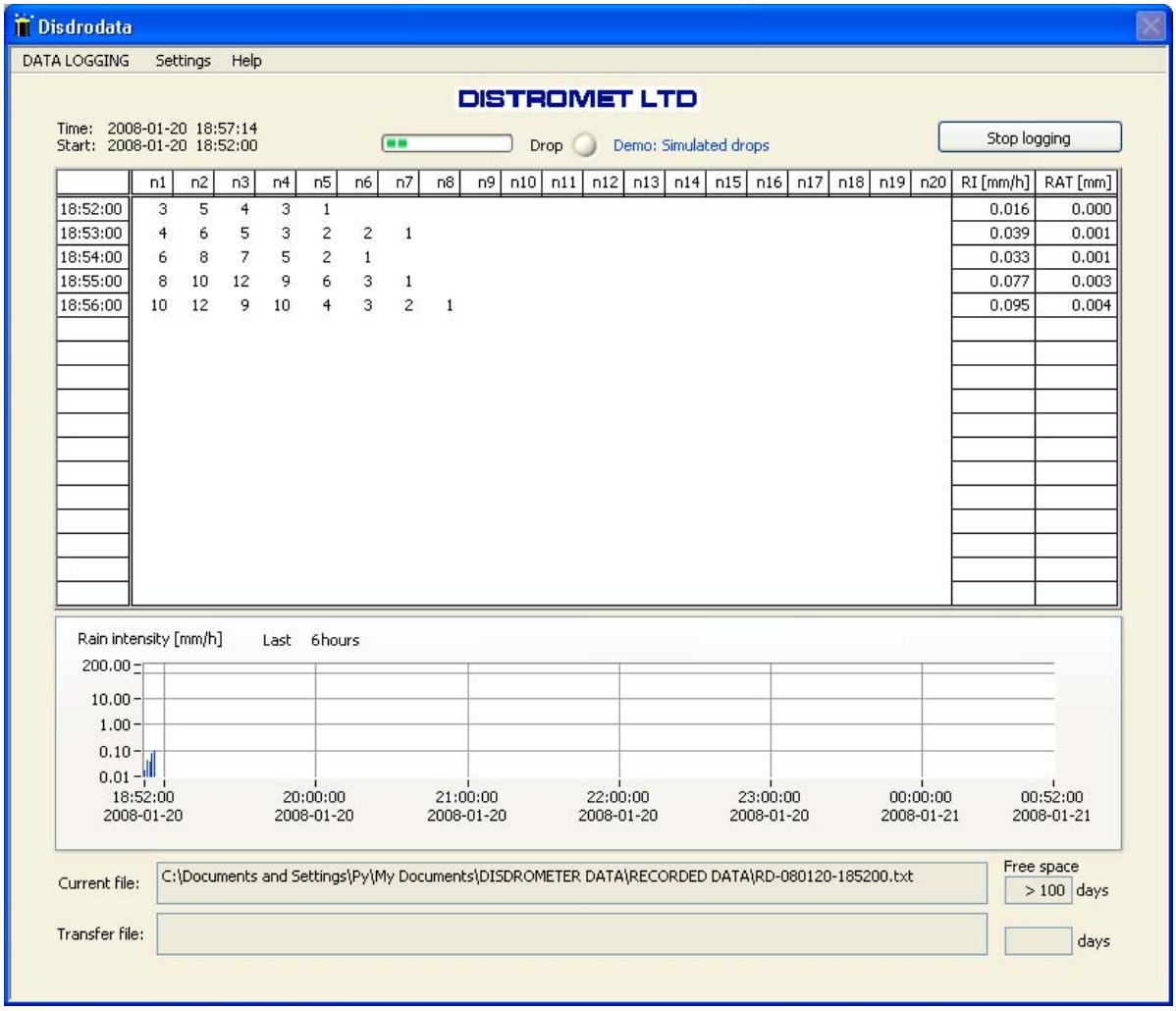


DISDROMETER DATA and subdirectories are created in your personnel file section on drive C. If necessary, they can also be located elsewhere e.g. if you have a data section on drive D or if you want data to be accessed by all users.

2.3.4.2 File format for RECORDED DATA

Refer to Appendix 4.5

2.3.5 Main window for data logging



After the START button has been pushed (according to 2.3.4) wait until the indicated start time has been reached and the data logging process starts. (green progress bar is active, showing the time interval).
If there is rain, the drop indicator (red light) will flash each time a drop hits the sensor.
This window displays the drop counts for each size class within the last 17 sampling intervals.
In the lower part of the window rain intensity is represented as an overview of the last hours of measurement. (Maximum 48 hours for a time interval of 60 seconds).

2.3.6 Testing readiness of installation

- Connect all components (sensor, processor and PC) and switch on power.
- Start Disdrodata and start DATA LOGGING (2.3.3 and 2.3.4).
- Press button “Test” on RD-80 processor. Many drops for class 7 are now simulated and sent to the PC.
- If the sensor is properly connected to the processor, LED Nr. 4 will go on.
- If the processor is properly connected to the PC, the drop indicator in DISDRODATA will flash.
- Check in the table if many drops in class 7 are displayed after the next write cycle.

2.3.7 DATA LOGGING – Help

The pull down menu **Help** contains:

- **Program structure overview**
- **User guide** with chapters related to DATA LOGGING. See chapters **2.1 to 2.3.6**
- **About** with indication of the actual program version

3. The DATA PROCESSING Program

3.1 Purpose and main functions

View logged data, calulate parameters and distributions:

- Load data files for processing (recorded data or former results)
- Select time interval for calculating parameters and distributions
- Display results, table, graphs, distribution curve
- Save results in output file
- Print results on standard printer
- Load demo data to explore program functionality and options

3.2 Calculate parameters and distributions

A rain drop size distribution is commonly represented by the function N(D), the number concentration of rain drops with the diameter D in a given volume of air. Because of the complicated processes involved in the formation of precipitation the function N(D) is very variable and cannot be given in a simple form. In many cases however a drop size distribution can be approximated fairly well by an exponential law and the following parameterisation can be used to characterise it:

$$N(D) = N_0 * \exp(-\Lambda \cdot D)$$

where N_0 is the number concentration of drops with diameter 0 on the exponential approximation and Λ (LAMBDA) is it's slope.

In many practical cases where knowledge of the whole drop size distribution is not necessary, other quantities derived from the drop size distribution like rainfall rate RI, liquid water content in a given volume Wg, radar reflectivity factor Z etc. can be used.
The following quantities are calculated and displayed:

Input data ni = number of drops measured in every drop size class i during time interval t .

Results

RI	Rainfall intensity (rainfall rate), [mm/h]
RA	Rain amount, [mm]
RAT	Total rain amount since the start of the measurement, [mm]
Wg	Liquid water content, [g/m^3]
ZdB	Radar reflectivity factor, [dB]
EF	Energy flux, [J/(m$^2 \cdot$ h)]
Dmax	Largest drop collected, [mm]
N(Di)	The number density of drops of the mean diameter corresponding to size class i per unit volume, [1/(m$^3 \cdot$mm)]
N_0	The number concentration, [1/(m$^3 \cdot$mm)]
Λ	Slope, [1/mm]

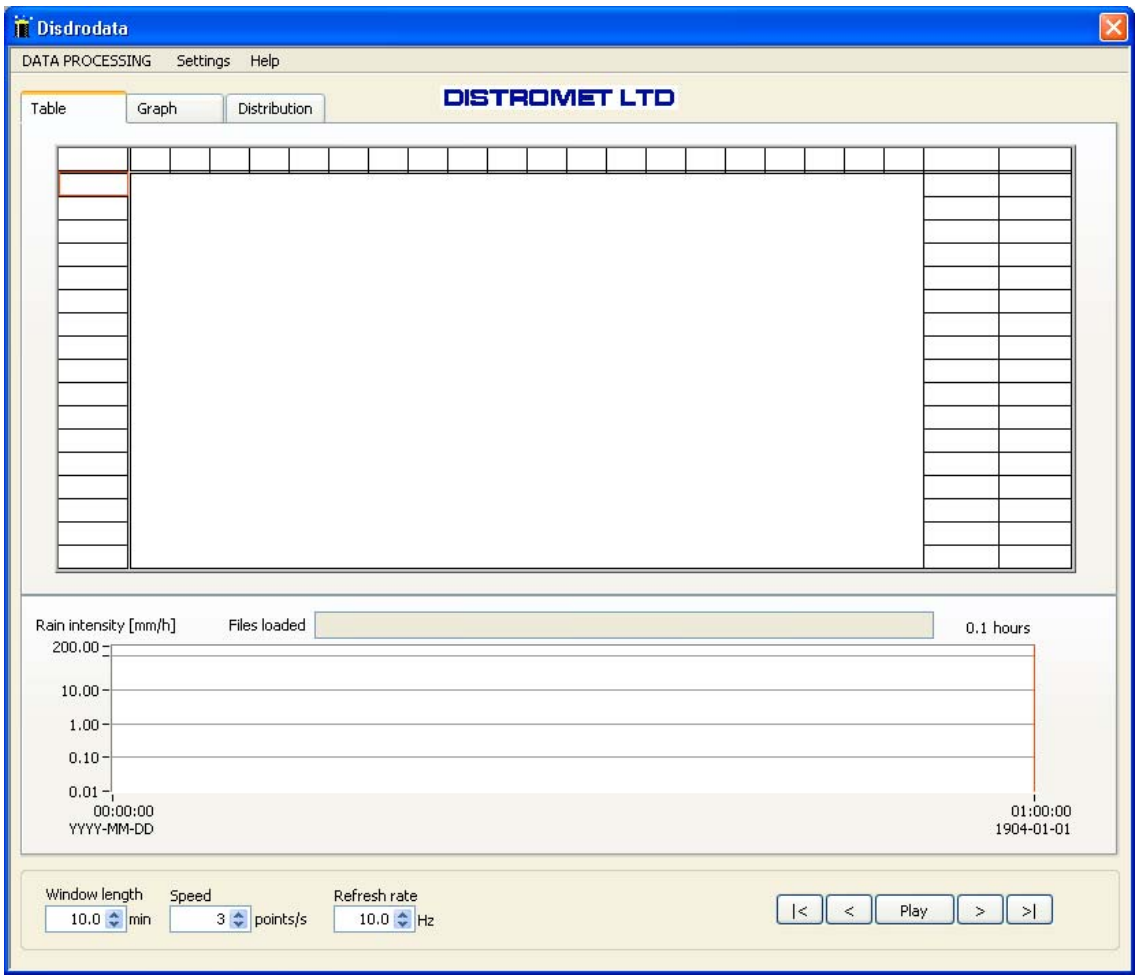
All quantities, RI through Λ, are calculated for a time interval t = T2 of your choice. Results can be transfered to an output file by using the *Save results* procedure.(See 3.3.4)

Formulas used for calculations are listed in Appendix 4.3

3.3 How to use DATA PROCESSING

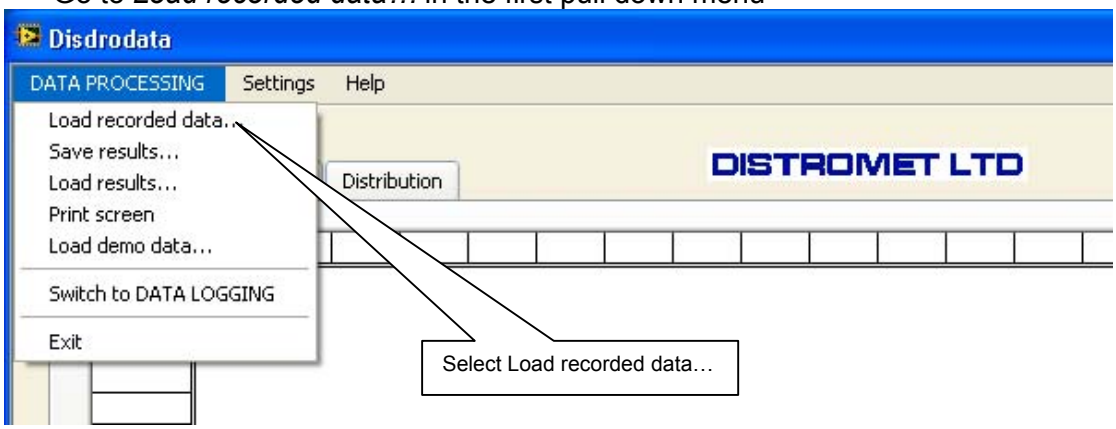
☞ Start DISDRODATA by using the provided link during installation or by running DISDRODATA.exe.
☞ Select DATA PROCESSING using the first pull down menu.

The following window must be present.

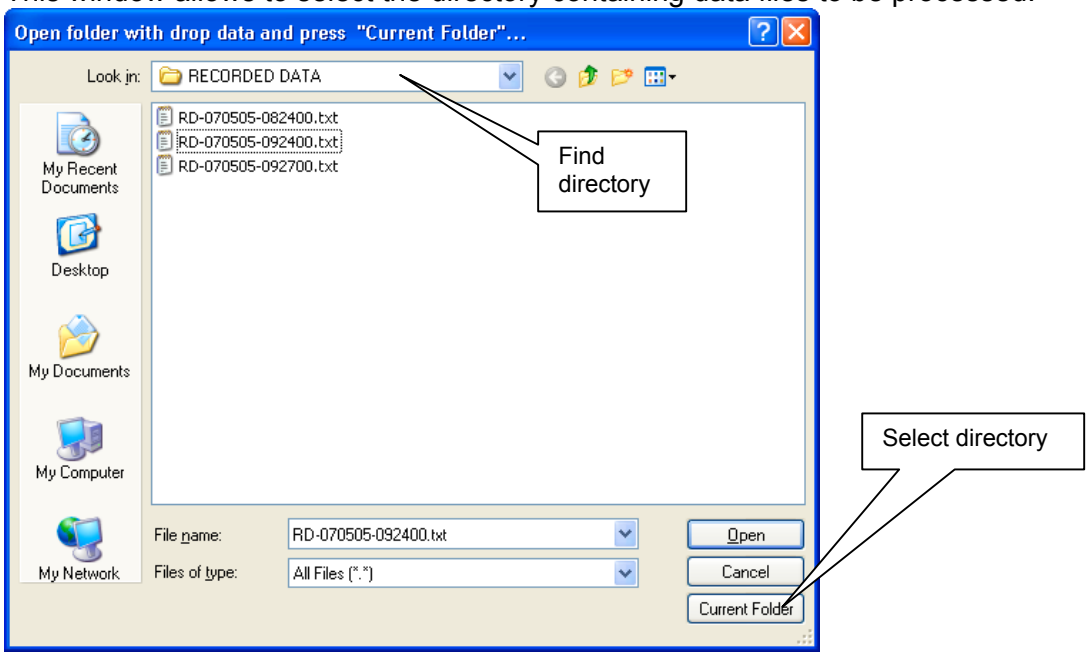


3.3.1 Load and display data

☞ Go to *Load recorded data…* in the first pull down menu

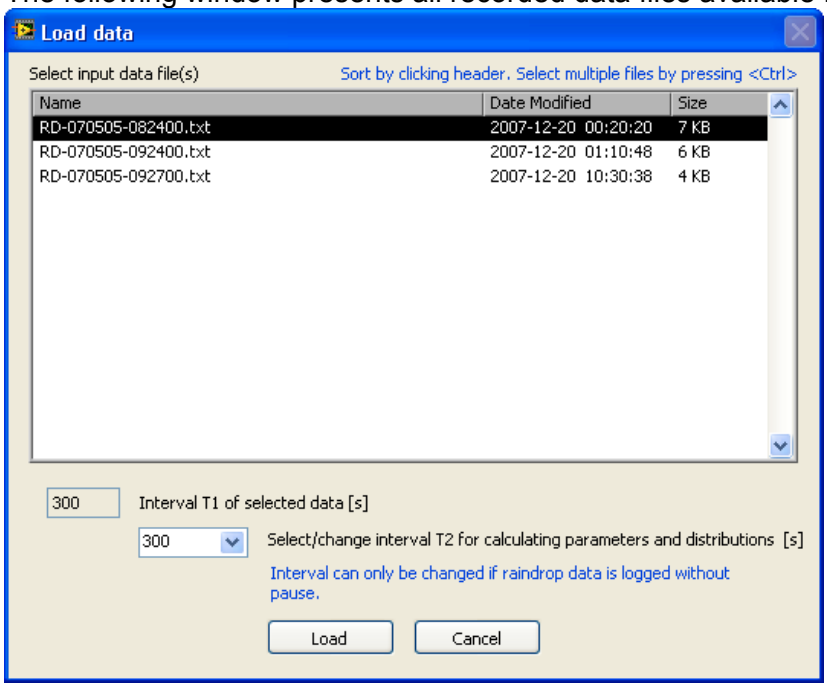


This window allows to select the directory containing data files to be processed:



☞ Select RECORDED DATA, the directory which has been used in the data logging process, for storing data. (See **2.3.4** pull down menu / start logging)

The following window presents all recorded data files available for calculations.



☞ First select one or more files by mouse click on the file name.

☞ Then select time interval T1 for calculating parameters and distributions.

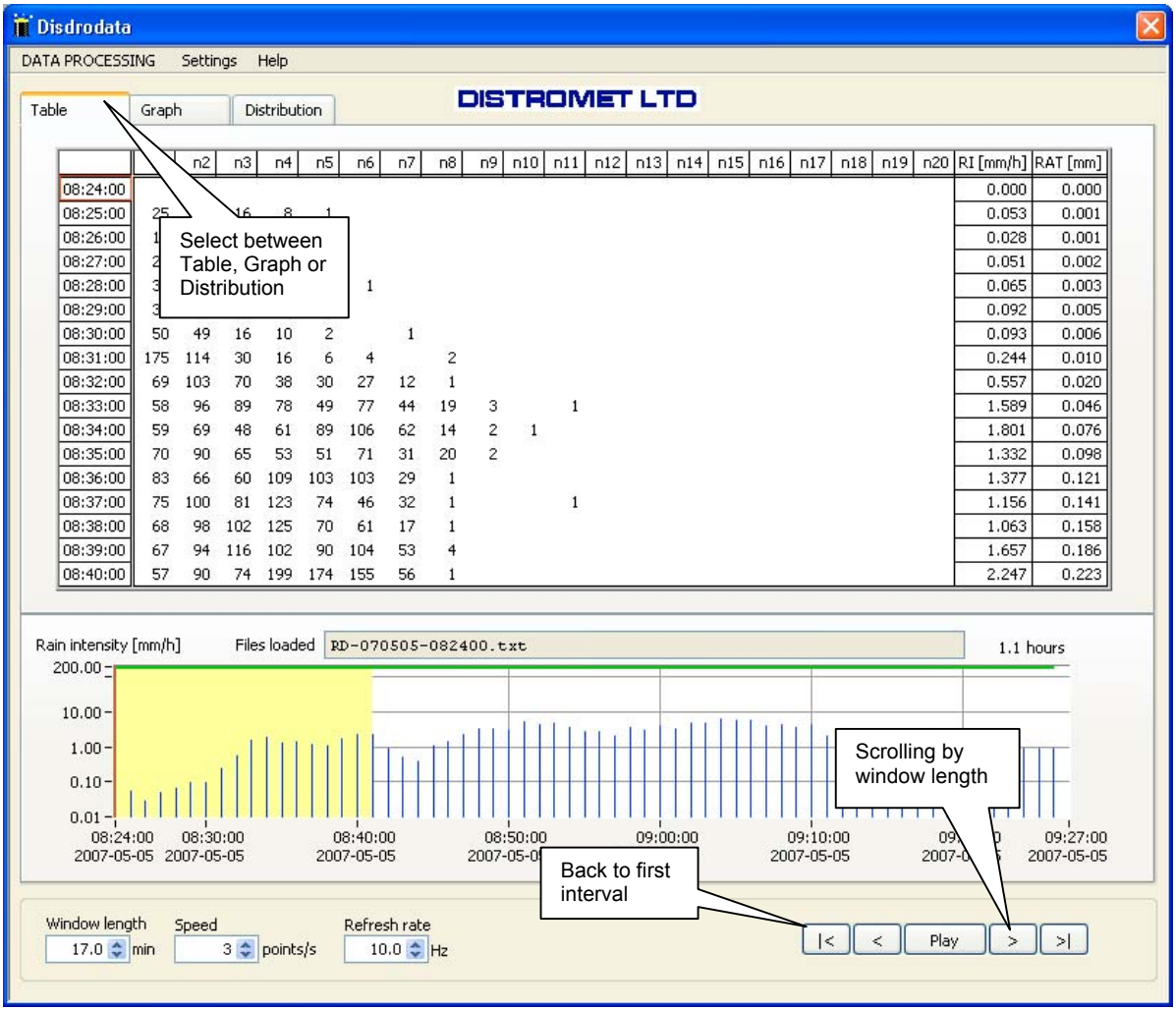
The interval T2 can be identical to the interval T1 of recorded data or can be a multiple of T1. E.g.: If the interval T2 is set to 300s, drop counts with a sampling interval of 60s will be cumulated within 300s and the resulting distribution curve is also displayed for intervals of 300 seconds.

☞ Press the load button.
The program starts to load and to calculate all parameters and graphs.

3.3.2 Results – table, graphs, distributions

The results are presented as table, graphs or distribution curves.

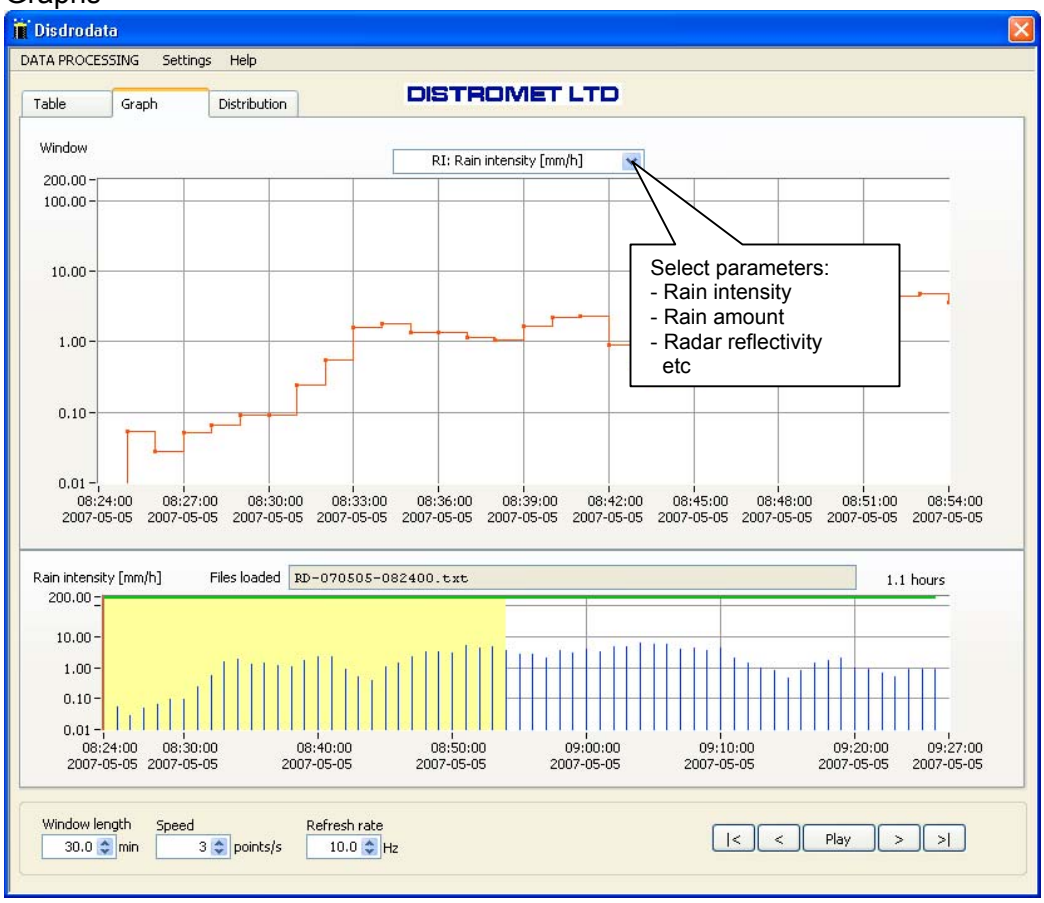
Table



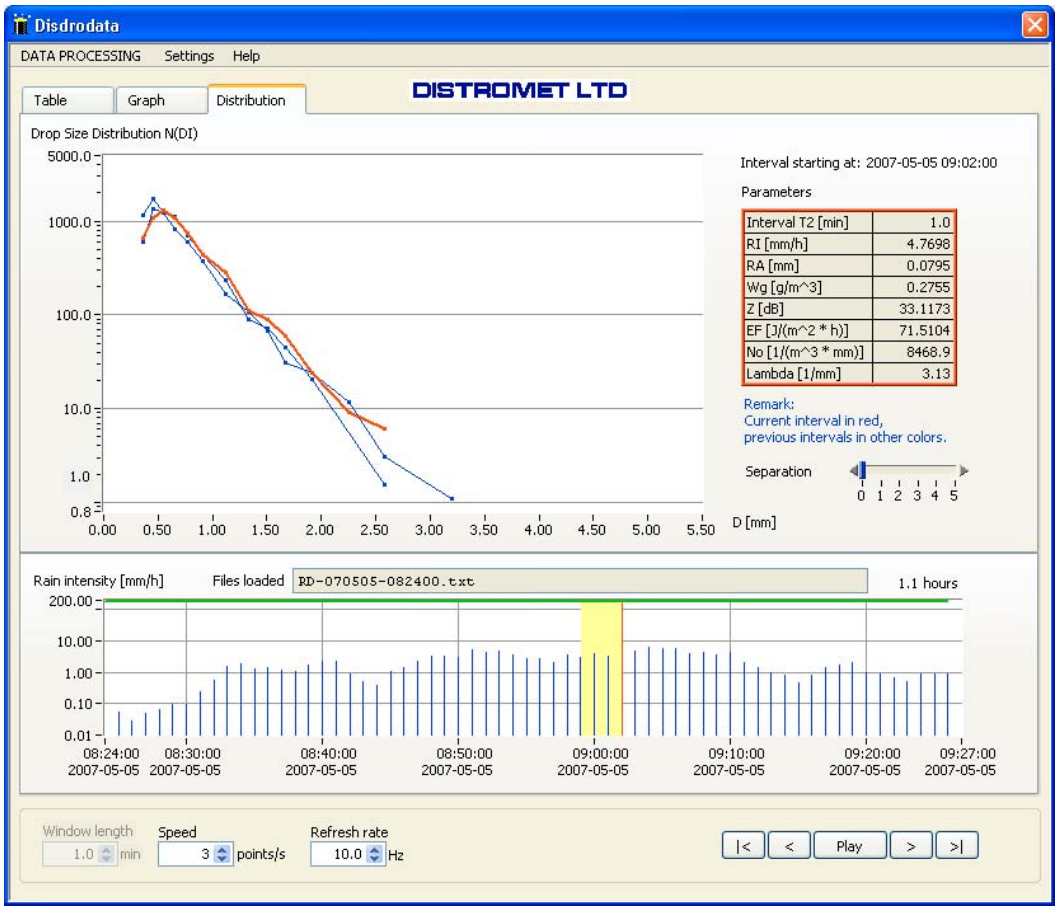
	n2	n3	n4	n5	n6	n7	n8	n9	n10	n11	n12	n13	n14	n15	n16	n17	n18	n19	n20	RI [mm/h]	RAT [mm]
08:24:00																				0.000	0.000
08:25:00	25		16	8	1															0.053	0.001
08:26:00	1																			0.028	0.001
08:27:00	2																			0.051	0.002
08:28:00	3				1															0.065	0.003
08:29:00	3																			0.092	0.005
08:30:00	50	49	16	10	2		1													0.093	0.006
08:31:00	175	114	30	16	6	4		2												0.244	0.010
08:32:00	69	103	70	38	30	27	12	1												0.557	0.020
08:33:00	58	96	89	78	49	77	44	19	3		1									1.589	0.046
08:34:00	59	69	48	61	89	106	62	14	2	1										1.801	0.076
08:35:00	70	90	65	53	51	71	31	20	2											1.332	0.098
08:36:00	83	66	60	109	103	103	29	1												1.377	0.121
08:37:00	75	100	81	123	74	46	32	1			1									1.156	0.141
08:38:00	68	98	102	125	70	61	17	1												1.063	0.158
08:39:00	67	94	116	102	90	104	53	4												1.657	0.186
08:40:00	57	90	74	199	174	155	56	1												2.247	0.223

The program calculates parameters based on the formulas in **Appendix 4.3**

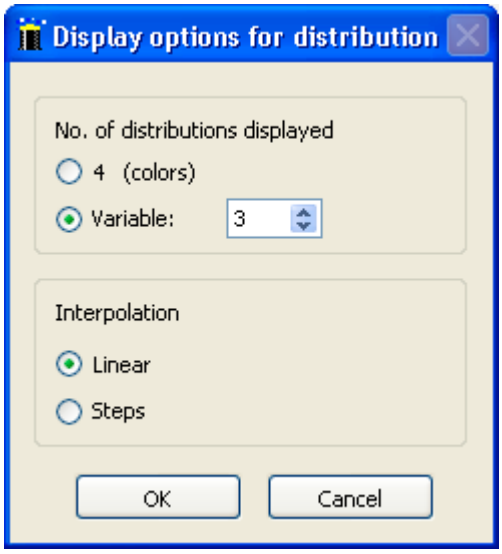
Graphs



Distributions

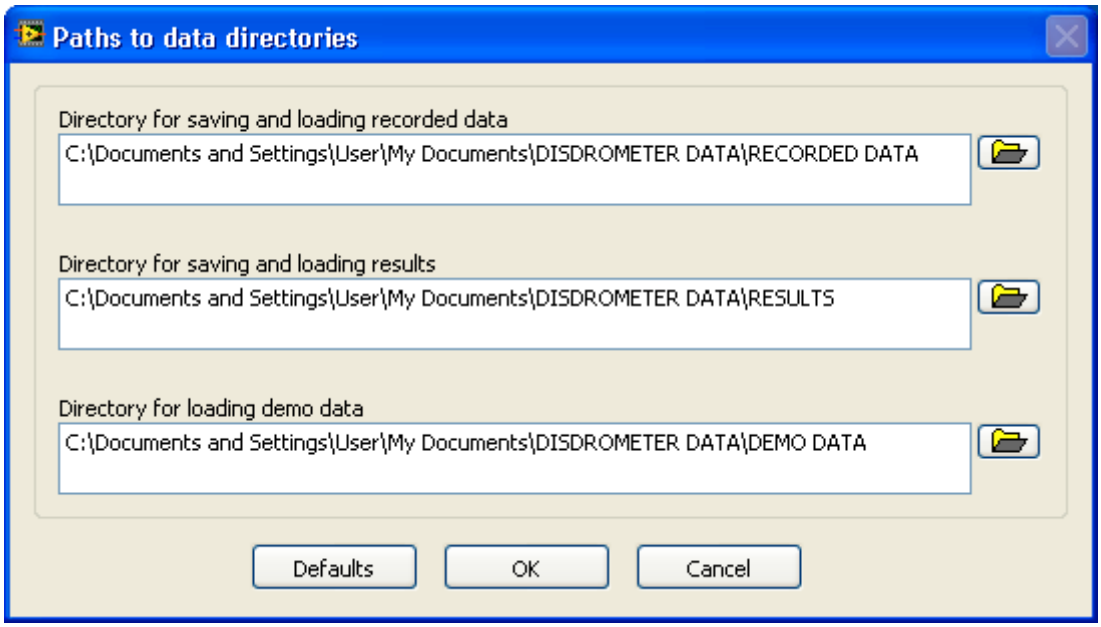


There are different ways of representing distributions. Go to the pull down menu *Settings* and select a convenient option.



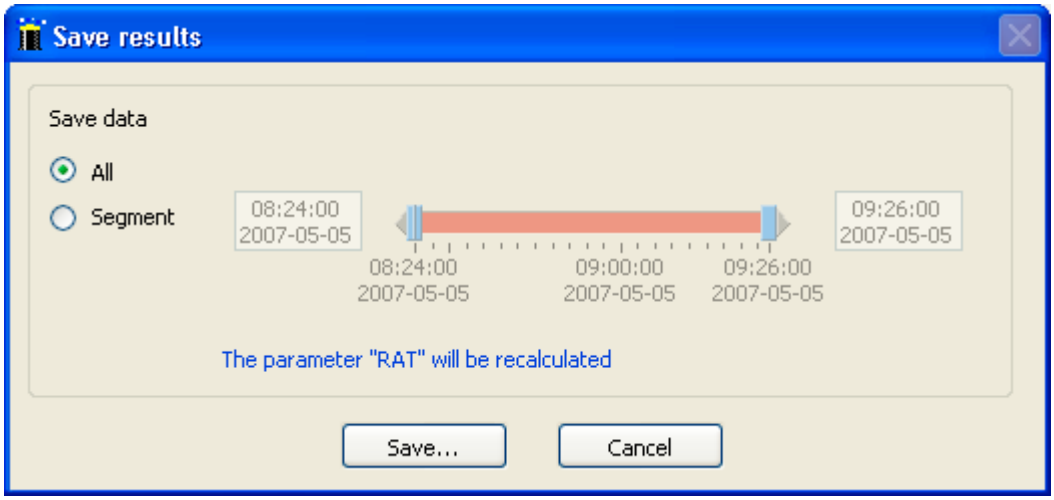
3.3.3 Paths to data directories

☞ Use the pull down menu and select: *Settings / Paths to data directories…*
The paths to the three most often used directories can be configured as follows:



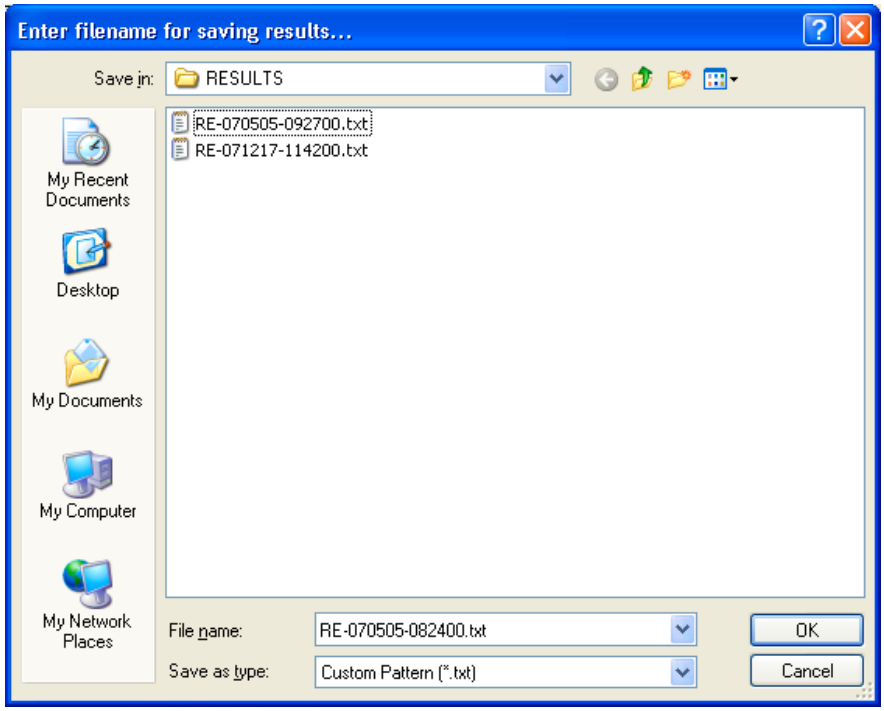
3.3.4 Save results

☞ Use the pull down menu and select: *Settings / Save results*
It is possible to save all data or a segment in order to eliminate uninteresting periods.



☞ Press the save button

The directory for RESULTS will appear, as it has been defined in *Settings/ Paths to data directories…*



The system proposes a file name beginning with RE (result) followed by the date and time stamp. This file name can be changed if necessary.

☞ Select directory to confirm, a result file will automatically be created.

3.3.4.1 Directory for results

Saved results can be re-examined and displayed at any time. Go to “Load results…” and select the **RESULTS** directory.

3.3.4.2 File format of saved data

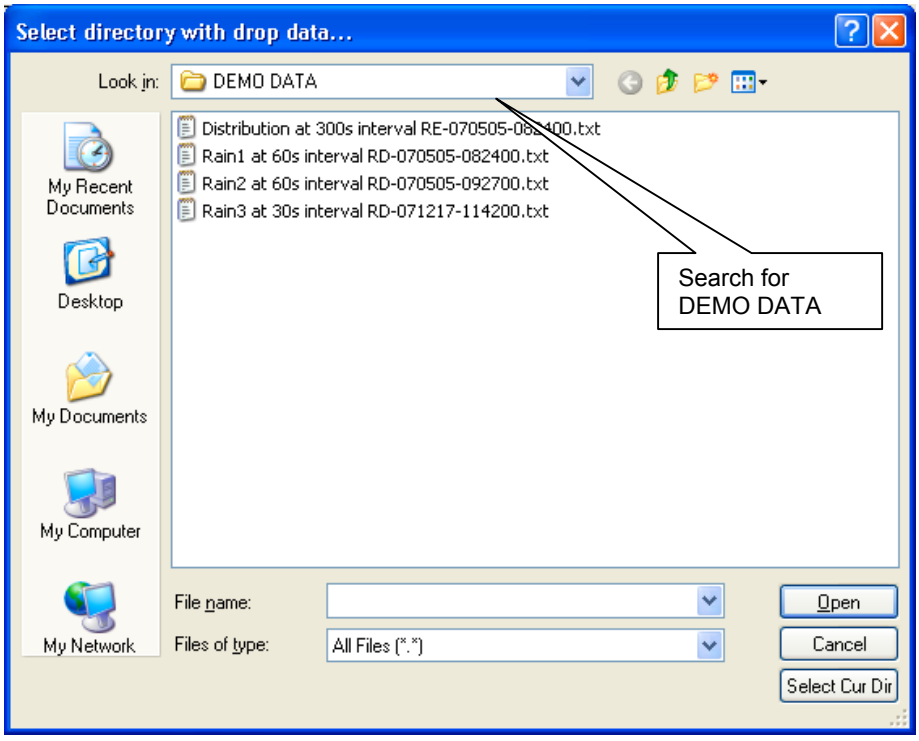
See Appendix 4.5

3.3.5 Print screen

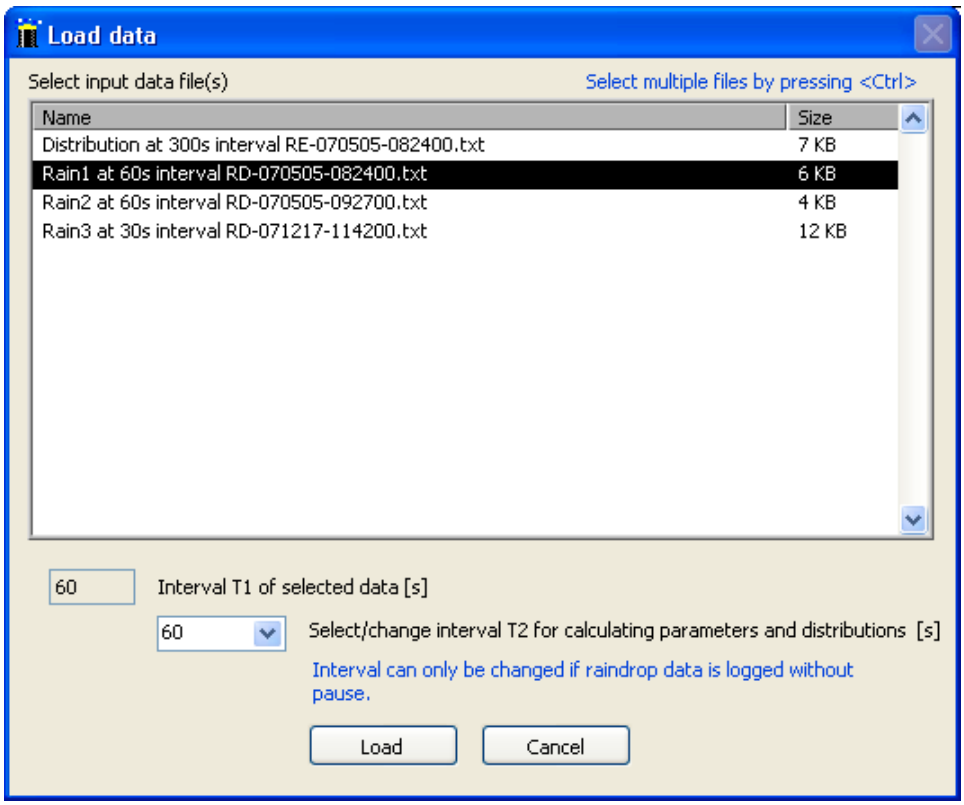
☞ Selecting *Print screen* in the pull down menu will initialize printing of the actual view on the printer which has been defined as standard printer of your system.

3.3.6 Load demo data

☞ Select *Load demo data…* in the first pull down menu:



☞ Select current directory **DEMO DATA**



- ☞ Select file by mouse click on the file name.
- ☞ select time interval for calculating parameters and distributions.
- ☞ Press the load button. Demo data will be displayed.

The interval T2 can be identical to the interval T1 of selected data or a multiple of T1. E.g.: If the interval T2 is set to 300s, drop counts with a 60s sampling interval will be cumulated within 300s. And the resulting distribution curve is displayed for an interval of 300 seconds.
More than one file may be selected if these files are chronologically consistent (file names and intervals).

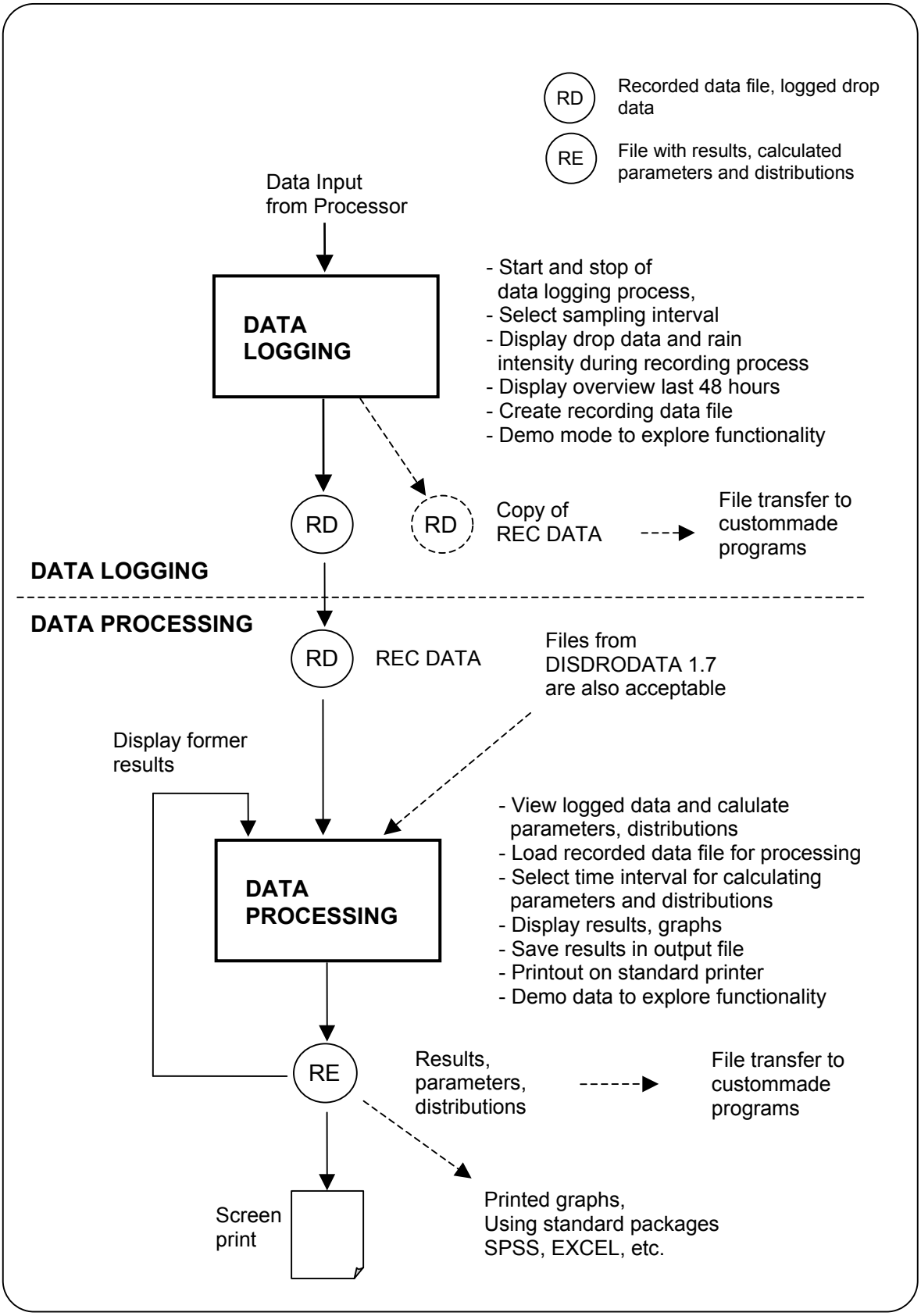
3.3.7 DATA PROCESSING – Help

The pull down menu **Help** contains:

- **Program structure overview**
- **User guide** with chapters related to DATA PROCESSING, see **3.1 to 3.3.6**
- **About** with indication of the actual program version

4. APPENDIX

4.1 Disdrodata - program structure overview



4.2 Drop size classes

Subdivision of the 127 drop sizes measured by the disdrometer RD-80 into 20 drop size classes of the DISDRODATA program.

Drop size class in DISDRODATA program	Output code of processor RD-80	Lower threshold of drop diameter mm	Average diameter of drops in class i, Di mm	Fall velocity of a drop with diameter Di, (1) v(Di) m/s	Diameter interval of drop size class i, Delta Di mm
1	1-13	0.313	0.359	1.435	0.092
2	14-23	0.405	0.455	1.862	0.100
3	24-31	0.505	0.551	2.267	0.091
4	32-38	0.596	0.656	2.692	0.119
5	39-44	0.715	0.771	3.154	0.112
6	45-54	0.827	0.913	3.717	0.172
7	55-62	0.999	1.116	4.382	0.233
8	63-69	1.232	1.331	4.986	0.197
9	70-75	1.429	1.506	5.423	0.153
10	76-81	1.582	1.665	5.793	0.166
11	82-87	1.748	1.912	6.315	0.329
12	88-93	2.077	2.259	7.009	0.364
13	94-98	2.441	2.584	7.546	0.286
14	99-103	2.727	2.869	7.903	0.284
15	104-108	3.011	3.198	8.258	0.374
16	109-112	3.385	3.544	8.556	0.319
17	113-117	3.704	3.916	8.784	0.423
18	118-121	4.127	4.350	8.965	0.446
19	122-126	4.573	4.859	9.076	0.572
20	127	5.145	5.373	9.137	0.455

(1)
Ref: Gunn, R. and G.D. Kinzer, 1949,
The Terminal Velocity of Fall for Droplets
in Stagnant Air. J. Meteor., Vol. 6, 243-248

4.3 Parameters and formulas

Input data for formulas

	Input data	**Dimensions**	**Details**
n_i	Number of drops measured in drop size class i during time interval t	---	Recorded data file
t	Time interval T1 for data logging, or Time interval T2 for calculations	s	Paragr. **2.3.1** Paragr. **3.3.1**
F	Size of the sensitive surface of the sensor	m^2	F= 0.005 m^2
D_i	Average diameter of drops in class i	mm	Appendix 4.2
$v(D_i)$	Fall velocity of drop with diameter D_i	m/s	Appendix 4.2
ΔD_i	Diameter interval of drop size class i	mm	Appendix 4.2

The following quantities are calculated for each time interval t:

	Parameters and formulas	**available after**	
		LOGGING, in RD file	**PROCESSING in RE file**
RI	Rain intensity (= rainfall rate), [mm/h] $$RI = \frac{\pi}{6} \cdot \frac{3.6}{10^3} \cdot \frac{1}{F \cdot t} \cdot \sum_{i=1}^{20} (n_i \cdot D_i^3)$$	•	•
RA	Rain amount, [mm] $$RA = RI \cdot t/3600$$	•	•
RAT	Total rain amount since start of measurement, [mm] $$RAT = \sum RA$$	•	•
W	Liquid water content, [mm^3/m^3] $$W = \frac{\pi}{6} \cdot \frac{1}{F \cdot t} \cdot \sum_{i=1}^{20} \left(\frac{n_i}{v(D_i)} \cdot D_i^3\right)$$		
Wg	Liquid water content, [g/m^3] $$Wg = W/1000$$		•
Z	Radar reflectivity factor, [mm^6/m^3] $$Z = \frac{1}{F \cdot t} \cdot \sum_{i=1}^{20} \left(\frac{n_i}{v(D_i)} \cdot D_i^6\right)$$		

ZdB	Radar reflectivity factor, [dB] $ZdB = 10 \cdot \log Z$		•
EK	Kinetic Energy, [J/m^2] $EK = \frac{\pi}{12} \cdot \frac{1}{F} \cdot \frac{1}{10^6} \cdot \sum_{i=1}^{20} \left(n_i \cdot D_i^{\,3} \cdot v(D_i)^2 \right)$		
EF	Energy flux, [J/(m^2 . h)] $EF = EK \cdot 3600/t$		•
N_0	Number concentration [1/(m^3 · mm)] $N_0 = \frac{1}{\pi} \cdot \left(\frac{6!}{\pi} \right)^{\frac{4}{3}} \cdot \left(\frac{W}{Z} \right)^{\frac{4}{3}} \cdot W$		•
Λ	Slope, [1/mm] $\Lambda = \left(\frac{6!}{\pi} \cdot \frac{W}{Z} \right)^{\frac{1}{3}}$		•
$N(D_i)$	Number density of drops of the diameter corresponding to size class i per unit volume, [1/(m3 . mm)] $N(D_i) = \frac{n_i}{F \cdot t \cdot v(D_i) \cdot \Delta D_i}$		•
D_{max}	Largest drop registered during interval t, [mm]		•

4.4 File format for recorded data (data logging)

The acquired data and some calculated parameters are saved in a large table. The values are in Tab-delimited ASCII-format which can be imported into other programs (e.g. Spreadsheet programs) for further analysis. There are headers which describe the available columns.

YYYY-MM-DD	hh:mm:ss	Status	Interval [s]	n1	n2	n3	n4	n5	n6	n7	n8
2007-02-14	19:47:00		60	0	50	3	7	9	23	48	47
2007-02-14	19:48:00		60	0	7	4	1	1	4	12	13
2007-02-14	19:49:00		60	0	48	2	2	3	13	8	23
etc.											

⟹

n14	n15	n16	n17	n18	n19	n20	RI [mm/h]	RA [mm]	RAT [mm]
2	2	4	4	6	6	4	19.7447	0.3291	0.3291
10	10	11	18	31	38	42	103.7771	1.7296	2.0587
0	0	0	0	0	0	0	5.0533	0.0842	2.1429

4.4.1 File name

The program generates the following file name automatically: RD-YYMMDD-hhmmss.txt (RD for Recorded Data, followed by the date and time).

4.4.2 File size

Estimated value in kBytes: F = 0.13 * T * 3600 / T1

F = maximum file size, with heavy rain (kB)
T = recording time (hours)
T1= interval for recording drop data (seconds)

4.5 File format for saving results (data processing)

YYYY-MM-DD	hh:mm:ss	Status	Interval[s]	n1	n2	n3	n4	n5	n6	n7	n8	n9	n10
2007-02-14	19:47:00		60	0	50	3	7	9	23	48	47	51	48
2007-02-14	19:48:00		60	0	7	4	1	1	4	12	13	21	33
2007-02-14	19:49:00		60	0	48	2	2	3	13	8	23	17	50
etc													

⟹

n16	n17	n18	n19	n20	RI [mm/h]	RA [mm]	RAT [mm]	Dmax [mm]	Wg [g/m^3]	Z [dB]
4	4	6	6	4	19.7447	0.3291	0.3291	5.373	0.7154	49.6027
11	18	31	38	42	103.7771	1.7296	2.0587	5.373	3.286	58.286
0	0	0	0	0	5.0533	0.0842	2.1429	1.912	0.2417	33.873

⟹

EF [J/(m^2 * h)]	No [1/(m^3 * mm)]	Lambda [1/mm]	N(d1)	N(d2)	N(d3)	N(d4)
669.2336	497.3545	1.2157	0	895.0949	48.4738	72.8375
4091.533	1212.9717	1.0377	0	125.3133	64.6317	10.4054
89.4366	4945.7646	2.8316	0	859.2911	32.3159	20.8107

⟹

N(d5)	N(d6)	N(d7)
84.9262	119.9183	4.78523
9.4362	20.8554	1035.7
28.3087	67.7799	559.056

⟹

N(d17)	N(d18)	N(d19)	N(d20)
3.5884	5.002	3.8525	3.2072
16.148	25.8437	24.399	33.6754
0	0	0	0

4.5.1 File name

The program generates the following file name automatically: RE-YYMMDD-hhmmss.txt
(RE for Results, followed by the date and time)

4.6 Contact

FOR FURTHER INFORMATION CONTACT OR VISIT OUR WEB SITE **info@distromet.com**

FOR FREQUENTLY ASKED QUESTIONS: **www.distromet.com**