FELDER, S. (2013): "Air-Water Flow Properties on Stepped Spillways for Embankment Dams: Aeration, Energy Dissipation and Turbulence on Uniform, Non-Uniform and Pooled Stepped Chutes." Ph.D. thesis, School of Civil Engineering, The University of Queensland, 506 pages.

DA Air-water flow data and source code of data analysis software

In this digital appendix, the source code of the self-designed data analysis programs is explained in section DA.1. The source code files and the input files are presented in the folder "Air-water_flow_analysis_software" in ASCII format. In section DA.2, the experimental results for all air-water flow experiments are explained and the result files are attached in the folder "Results_air-water_flows_stepped_spillways". The ASCII result files are sorted in folders according to the experimental facility, the step configuration and the measurement instrumentation. All folders with result files are compressed in ZIP format to minimise the data volume. It is recommended to use freely available ZIP software (e.g. WinZip, 7zip, etc.) to access the result files and to read the result files with a text editor. All data analysis programs are the intellectual property of the author. The software is open access, but the author of the software must be acknowledged.

DA.1 Source code of data analysis software

For all air-water flow experiments in the present study, self-designed data analyses software in Fortran was used for the pre-processing of the raw Voltage signals. The data analysis software allowed the automated and time-efficient calculation of the full range of air-water flow properties measured with conductivity probes in Windows XP & 7. The Fortran source code of the data analysis programs is documented in the folder "Air-water_flow_analysis_software\Fortran_code_ASCII" in ASCII format. Three different data analysis source code txt-files are provided:

- Data_analysis_software_double_tip_probe
- Data_analysis_software_2single_tip_probes
- Triple_decomposition_analysis_software

All data analysis source codes are designed to create executable software files with a Fortran compiler. Further details about the three data analysis programs are provided in the following subsections.

DA.1.1 Data analysis software for a double-tip conductivity probe

The source code for the data analysis software for a double-tip conductivity probe is documented in the txt-file "Data_analysis_software_double_tip_probe ". Table DA-1 lists the air-water flow properties and the signal processing technique for the double-tip conductivity probe data which were developed and used in previous studies at the University of Queensland (e.g. CHANSON & TOOMBES 2002a; TOOMBES 2002; CHANSON & CAROSI 2007a, FELDER & CHANSON 2009a). The Fortran data analysis program automated the calculation of the air-water flow properties (Table DA-1) and the output included ASCII files with results of void fraction, bubble count rate, interfacial velocity, turbulence intensity, chord times and lengths, auto- and cross-correlation functions, auto- and cross-correlation time scales, integral turbulent time and length scales, inter-particle arrival times and the full range of cluster properties for three different cluster definitions. More details about the calculation of the air-water flow properties were provided in section 2.5. For all experiments with the double-tip conductivity probe, the air-water flow properties are presented in the folder "Results_air-water_flows_stepped_spillways" and further details about the result files are documented in section DA.2. The new code enabled a much faster and efficient signal processing and it was successfully used in air-water flow studies (FELDER & CHANSON 2011a,b;2012a; CHACHEREAU & CHANSON 2011a; ZHANG et al. 2012,2013; FELDER et al. 2012a,b; GUENTHER et al. 2013).

Table DA-1: Summary of the signal processing techniques of the air-water flow properties with the double-tip conductivity probe

Parameter	Notation	Unit	Signal processing	Basic instrumentation
Void fraction	C	-	Single threshold	Single-tip probe
Bubble count rate	F	Hz	Single threshold	Single-tip probe
Interfacial velocity	V	m/s	Statistical analysis	Double-tip probe
Turbulence intensity	Tu	-	Statistical analysis	Double-tip probe
Bubble/droplet chord time	t_{ch}	s	Single threshold	Single-tip probe
Bubble/droplet chord length	ch	m	Single threshold	Double-tip probe
Auto-correlation function	R_{xx}	-	Statistical analysis	Single-tip probe
Cross-correlation function	R_{xy}	-	Statistical analysis	Double-tip probe
Maximum cross-correlation coefficient	$(R_{xy})_{max}$	-	Statistical analysis	Double-tip probe
Auto-correlation time scale	T_{xx}	s	Statistical analysis	Single-tip probe
Cross-correlation time-scale	T_{xy}	s	Statistical analysis	Double-tip probe
Cluster analysis based upon near-wake, constant and percentage criterions	-	-	Single threshold	Single-tip probe
Inter-particle arrival time	-	s	Single threshold	Single-tip probe

The data acquisition program for all phase-detection intrusive probes was designed as execution file with command window interaction (Figure DA-1). Figure DA-1 shows a screenshot of the command window for the data analysis software for a double-tip conductivity probe signal. The program asked at the beginning for the filenames of three ASCII input files with lists of characteristic calculation parameters, of the raw voltage input data files and of the measurement positions (section DA.1.4). Further details about the three input files are provided in section DA.1.4. After input of the external files, the data analysis software analysed the data fully automatically giving feedback about the calculation position and the progress. The data analyses time for all voltage raw data in a cross-section (≈ 30 – 35 data points, sampling duration 45 s, sampling rate 20 kHz) took about 25 minutes. All air-water flow properties were calculated for each measurement position and the output consisted of several ASCII files including files of auto- and cross-correlations, PDF functions of the raw voltage signal and the air-water interfaces for each position and summary files of the basic air-water flow properties, the turbulence and velocity data, the chord times and chord length, the inter-particle arrival times and the cluster properties for three calculation criteria. The ASCII format of the result files enabled a simple drawing of the calculation results. More details about the output data format, the naming of the result files and the calculated parameters are presented in DA.2.

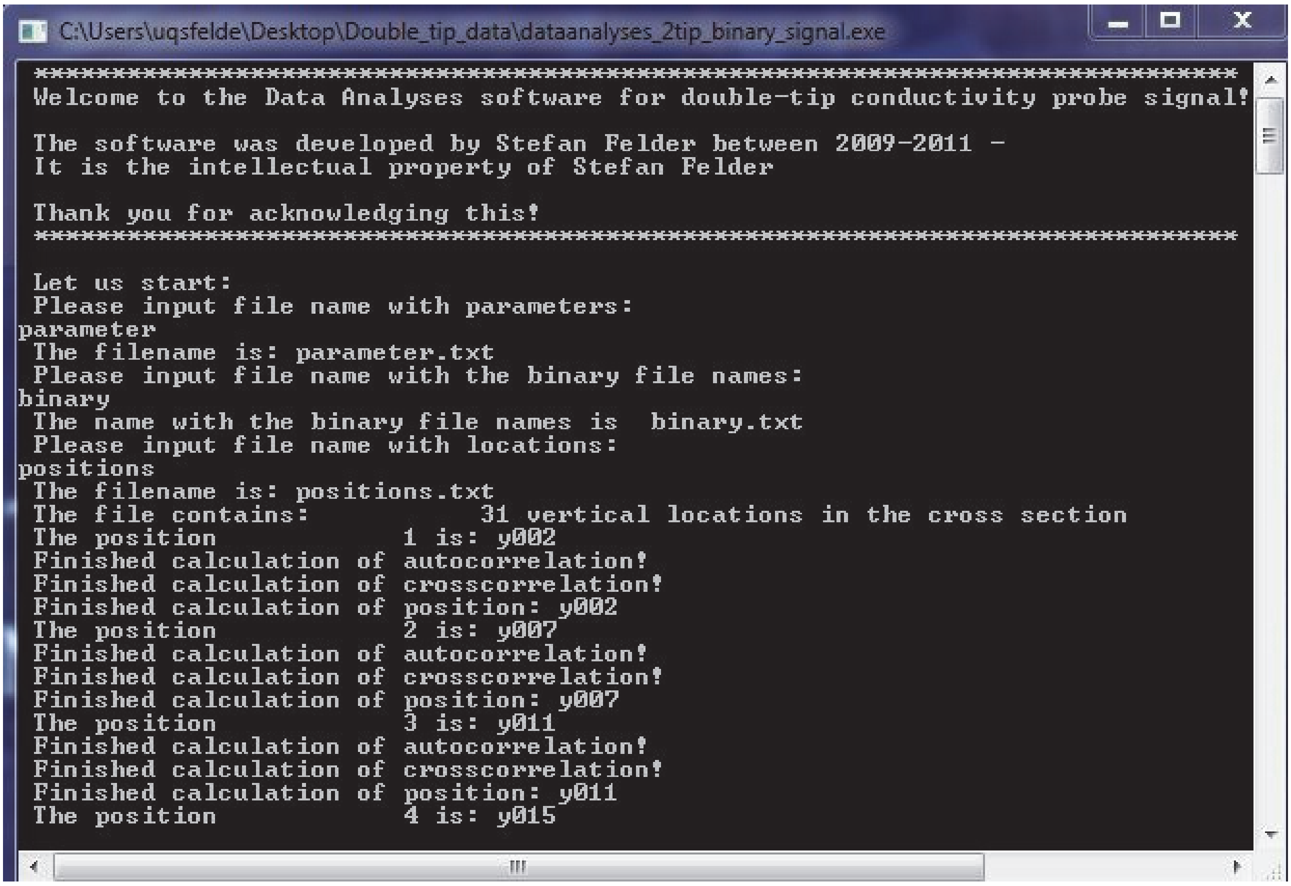

Figure DA-1: Screenshot of the command window of the self-designed data analysis software in Fortran

DA.1.2 Data analysis software for array of two single-tip conductivity probes

The source code for the data analysis software for an array of two single-tip conductivity probes is provided in the txt-file "Data_analysis_software_2single_tip_probes". The code in the ASCII file must be compiled in a Fortran compiler to create an executable file for the data analysis program. The working principle of the software is identical to the data analysis program for a double-tip conductivity probe (section DA.1.1). Furthermore, the input files and output results files are in agreement. The data analysis software for the array of two single-tip probes analyses automatically the full range of air-water flow properties (Table DA-2). Table DA-2 summarises the air-water flow properties resulting from the measurements with an array of two single-tip probes. Some more details about the calculation methods are provided in the main part of the thesis in section 2.5 and some details about the output ASCII files are presented in section DA.2.

All experimental results for the air-water flow measurements are available in the folder "Results_air-water_flows_stepped_spillways". The single-tip result files are labelled with "*single-tip".

Table DA-2: Summary of the signal processing techniques of the air-water flow properties with an array of two single-tip conductivity probes

Parameter	Notation	Unit	Signal processing	Basic instrumentation
Void fraction	C	-	Single threshold	Single-tip probe
Bubble count rate	F	Hz	Single threshold	Single-tip probe
Bubble/droplet chord time	t_{ch}	s	Single threshold	Single-tip probe
Auto-correlation function	R_{xx}	-	Statistical analysis	Single-tip probe
Cross-correlation function	R_{xz}	-	Statistical analysis	Array of 2 single-tip probes
Maximum cross-correlation coefficient	$(R_{xz})_{max}$	-	Statistical analysis	Array of 2 single-tip probes
Auto-correlation time scale	T_{xx}	s	Statistical analysis	Single-tip probe
Cross-correlation time-scale	T_{xz}	s	Statistical analysis	Array of 2 single-tip probes
Integral turbulent time scale	T_{int}	s	Statistical analysis	Array of 2 single-tip probes
Integral turbulent length scale	L_{xz}	m	Statistical analysis	Array of 2 single-tip probes
Cluster analysis based upon near-wake, constant and percentage criterions	-	-	Single threshold	Single-tip probe
Inter-particle arrival time	-	s	Single threshold	Single-tip probe

DA.1.3 Triple decomposition analysis software for instationary air-water flows

The third data analysis software is designed for instationary air-water flows on pooled stepped spillways with flat channel slope and hydraulic jumps. A triple decomposition approach for the instationary air-water flow voltage signal was developed to identify the 'true' turbulent contribution of the fast fluctuating velocity (section 2.7; Appendix D). The calculation was very extensive and the Fortran data analysis software was expanded to include also the triple decomposition technique. The source code is provided in ASCII format in the txt-file "Triple_decomposition_analysis_software".

The triple decomposition software comprised the filtering of the raw voltage signals of a double-tip conductivity probe into the high pass, band pass and low pass filtered signals using a common FFT approach (PRESS et al. 2007). For each of the filtered components, auto- correlation and cross-correlation analyses were performed and a range of air-water flow properties was calculated (Table DA-3). The calculated air-water flow properties are presented in Table DA-3 for some lower and upper cut-off frequencies of 0.33 Hz and 10 Hz respectively. Furthermore, some cross-correlation analyses were performed between the different filtered components and some factors of proportionality were calculated. Please find more details about the calculated parameters in the triple decomposition approach in section 2.7, Appendix D and section DA.2.3.

Table A-3: Summary of some investigated parameters in the triple decomposition analyses software

Parameter	Signal components			
	Raw data	Band pass filtered data (0.33-10 Hz)	High pass filtered data (10-10000 Hz)	Calculated data of sum of correlation functions of band and high pass filtered components
Auto-correlation function [-]	R_{xx}	$R_{xx}' = \alpha \times R_{x'x'}$	$R_{xx}'' = \beta \times R_{x''x''}$	$R_{xx}^{(1)} = \alpha \times R_{x'x'} + \beta \times R_{x''x''}$
Cross-correlation function [-]	R_{xy}	$R_{xy}' = A \times R_{x'y'}$	$R_{xy}'' = B \times R_{x''y''}$	$R_{xy}^{(1)} = A \times R_{x'y'} + B \times R_{x''y''}$
Maximum cross-correlation [-]	$(R_{xy})_{max}$	$(R_{xy})'_{max}$	$(R_{xy})''_{max}$	$(R_{xy})^{(1)}_{max}$
Cross-correlation time scale [s]	T_{xy}	T_{xy}'	T_{xy}''	$T_{xy}^{(1)}$
Auto-correlation time scale [s]	T_{xx}	T_{xx}'	T_{xx}''	$T_{xx}^{(1)}$
Interfacial velocity [m/s]	V	V'	V''	$V^{(1)}$
Turbulence intensity [-]	Tu	Tu'	Tu''	$Tu^{(1)}$

The calculations were very extensive and the implementation of the triple decomposition technique would be impossible without the Fortran triple decomposition analysis software. The calculation time with the Fortran program on a personal computer with Intel Core i7 processor (4 GB RAM) took about 10-12 hours for a single cross-section with 30-35 data points (sampling duration 45 s, sampling rate 20 kHz). The execution of the triple decomposition analyses software was similar to the data analyses software (section DA.1.1) and comprised an executable file, a command window interaction and three input ASCII files with information about the parameters, the raw data files and the measurement positions (section DA.1.4). A screenshot of a typical command window during the triple decomposition analyses is illustrated in Figure DA-2. The command structure of the triple decomposition analyses software was similar to the data analyses software (Figure DA-2), but included further calculation parameters in the parameter input file. For the raw signal and each filtered signal component, several output files in ASCII format were calculated including the filtered data and the auto- and cross-correlation functions for each measurement position as well as summary files of the air-water flow properties (section DA.2).

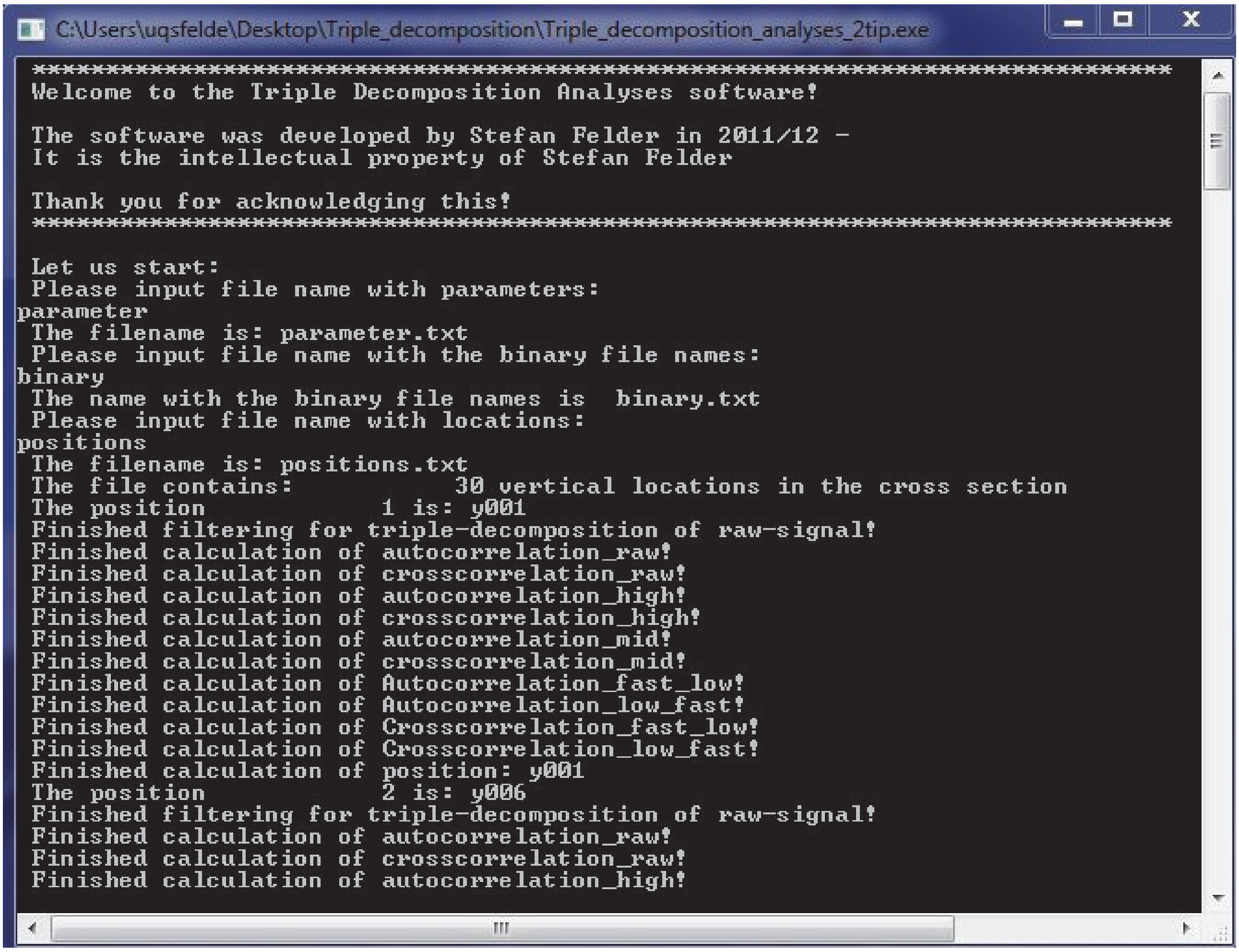

Figure DA-2: Screenshot of the command window of the self-designed triple decomposition analyses software

DA.1.4 Input files for data analysis software

In the data analysis programs, the command window asks for three input files. Some examples of the input txt-files are provided in the folder "Air-water_flow_analysis_software\Input_files":

- binary
- positions
- parameter
- parameter_triple_decomposition (file must be renamed to "parameter" for analysis)

All input files must be adjusted prior to the execution of the data analysis software and must be in the same folder as the executable file and the raw data files. The binary file is an input file containing a list of the raw data files recorded with the self-designed data acquisition program (see Appendix A). The recorded files are in binary format and must be of 8 character lengths. The positions file contains the list with the measurement positions perpendicular to the pseudo-bottom starting at the step edge (y = 0). Please note that the space for each measurement position must contain 4 characters. Both binary and positions files must contain the same amount of lines; otherwise the program will terminate. The parameters file contains the input parameters. The parameter are summarised in the example file and some short explanations are also provided in Table DA-4 in chronological order. Some additional parameters are used for the triple decomposition analyses comprising in chronological order the lower cut-off frequency, the upper cut-off frequency, the number for the fast Fourier transformation, the number of correlation steps for the band pass filtered signal and the number of correlation steps for the low pass filtered signal. Please note that an example parameter file for the triple decomposition technique with some additional parameters is also provided in the example input file (parameter_triple_decomposition). The file must be renamed to "parameter" before starting the triple decomposition analysis.

Table DA-4: Input parameters for the data analysis software for double-tip conductivity probe

Parameter	Comment
delta_x [mm]	Longitudinal distance between double-tip probe tips
Sampling frequency [Hz]	Sampling frequency for each probe sensor
Correlation steps	Number of steps for the auto- and cross-correlation analyses
Sampling duration [s]	Sampling duration for each probe sensor
Number of probes [-]	Number of simultaneously sampled conductivity probes
Number of sub-sample segments	Number of non-overlapping segments for correlation analyses
Bin size for voltage signal	Bin size of PDF of raw voltage signal for single threshold analysis
Maximum number of bubbles	Integer number for the allocation of calculation array
Single threshold value	Percentage value for the single threshold analysis
Bin size of PDF for chord length [mm]	Bin size for the PDF of chord length analyses
Bin size of PDF for chord time [ms]	Bin size for the PDF of chord time analyses
Minimum chord length [mm]	Smallest possible chord length in calculation
Maximum chord length [mm]	Largest possible chord length in calculation
Minimum chord time [ms]	Smallest possible chord time in calculation
Maximum chord time [ms]	Largest possible chord time in calculation
Integer	Parameter for mode of cluster analyses
Factor for percentage cluster criterion	Percentage value for cluster analyses with percentage criterion
Contact cluster factor	Factor for the constant cluster analyses criterion

DA.2 Experimental results of air-water flow experiments

The experimental results of the air-water flow experiments for all stepped spillway configurations are presented in the folder "Results_air-water_flows_stepped_spillways". The result files comprise air-water flow data on stepped spillways with slopes of 8.9º and 26.6º and configurations with flat uniform steps, flat non-uniform steps, pooled steps, pooled porous steps and combination of flat and pooled steps (Figure DA-3; Table DA-5). Figure DA-3 illustrates the stepped spillway configurations and Table DA-5 summarises the experimental flow conditions for the air-water flow measurements including the folder names of the result files. More details about the stepped spillway configurations and the experiments can be found in the main part of the thesis. For all experiments, air-water flow measurements were conducted with phase-detection intrusive probes for a sampling duration of 45 s and sampling rate of 20 kHz. The raw voltage signals were analysed with some self-designed data analysis software which were presented in section DA.1. The software provided a range of experimental results comprising the full range of air-water flow properties. In this section, the result files and the naming of the air-water flow properties are explained.

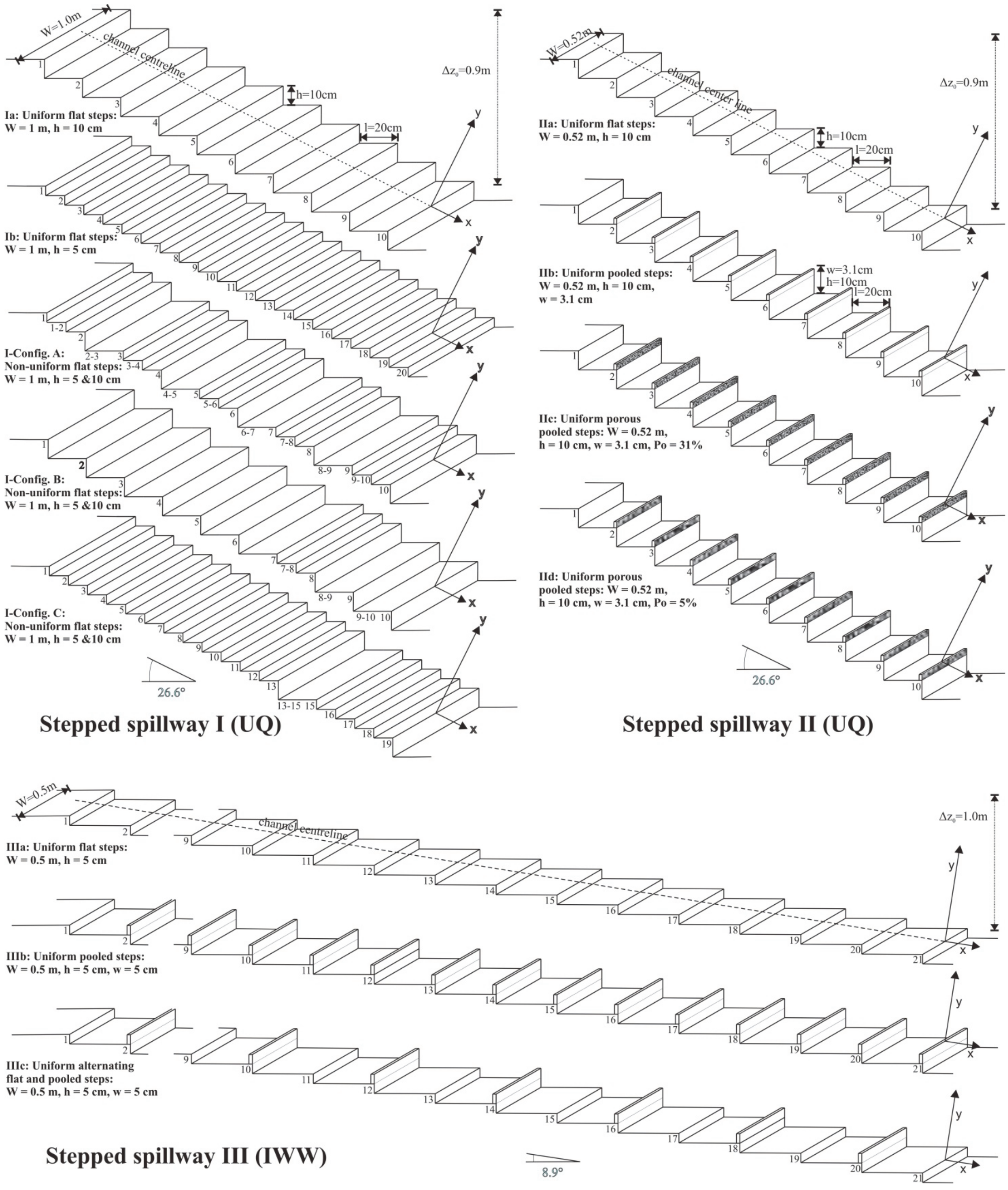

Figure DA-3: Stepped spillway configurations with flat and pooled steps; illustration of step numbering and definition of the pseudo-bottom position (y = 0)

Table DA-5: Experimental configurations of conductivity probe measurements and folder name with results files

Spillway/step characteristics	Conductivity probe	Com-ment	q_w [m^2/s]	d_c/h [-]	Re [-]	Folder name with result files
Ia (uniform flat) θ = 26.6º, W = 1 m h = 10 cm	Double-tip (Ø = 0.25 mm)	Step edges	0.056-0.227	0.69-1.74	2.2×10^5-9.0×10^5	Ia_double-tip_data
	Array of 2 single-tips (Ø = 0.35 mm)	Step edges	0.056-0.161	0.69-1.38	2.2×10^5-6.4×10^5	Ia_single-tip_data
	Double-tip (Ø = 0.25 mm) Array of 2 single-tips (Ø = 0.35 mm)	Cavity	0.143	1.28	5.7×10^5	Ia_step_cavity_data
Ib (uniform flat) θ = 26.6º, W = 1 m h = 5 cm	Double-tip (Ø = 0.25 mm)	Step edges	0.020-0.210	0.70-3.30	8.1×10^4-8.3×10^5	Ib_double-tip_data
	Array of 2 single-tips (Ø = 0.35 mm)	Step edges	0.042-0.116	1.14-2.22	1.7×10^5-4.6×10^5	Ib_single-tip_data
I-Config. A (non-uniform flat) θ = 26.6º, W = 1 m h = 5 & 10 cm	Double-tip (Ø = 0.25 mm)	Step edges	0.056-0.227	0.69-1.74	2.2×10^5-9.0×10^5	IConfig.A_double-tip
	Array of 2 single-tips (Ø = 0.35 mm)	Step edges	0.116	1.11	4.6×10^5	IConfig.A_single-tip
I-Config. B (non-uniform flat) θ = 26.6º, W = 1 m h = 5 & 10 cm	Double-tip (Ø = 0.25 mm)	Step edges	0.056-0.227	0.69-1.74	2.2×10^5-9.0×10^5	IConfig.B_double-tip
	Array of 2 single-tips (Ø = 0.35 mm)	Step edges	0.116	1.11	4.6×10^5	IConfig.B_single-tip
I-Config. C (non-uniform flat) θ = 26.6º, W = 1 m h = 5 & 10 cm	Double-tip (Ø = 0.25 mm)	Step edges	0.020-0.227	0.70-1.74	8.1×10^4-8.3×10^5	IConfig.C_double-tip
IIa (uniform flat) θ = 26.6º, W = 0.52 m h = 10 cm	Double-tip (Ø = 0.25 mm)	Step edges	0.073-0.186	0.82-1.52	2.9×10^5-7.4×10^5	IIa_double-tip_data
	Array of 2 single-tips (Ø = 0.35 mm)	Step edges	0.122-0.173	1.15-1.45	4.9×10^5-6.9×10^5	IIa_single-tip_data
IIb (pooled) θ = 26.6º, W = 0.52 m h = 10 cm, w = 3.1 cm	Double-tip (Ø = 0.25 mm)	Step edges	0.025-0.250	0.40-1.85	1.0×10^5-9.9×10^5	IIb_double-tip_data
	Double-tip (Ø = 0.25 mm)	Cavity	0.144	1.29	5.7×10^5	IIb_step_cavity_data
IIc (pooled porous) θ = 26.6º, W = 0.52 m h = 10 cm, w = 3.1cm Po = 31%	Double-tip (Ø = 0.25 mm)	Step edges	0.045-0.187	0.59-1.52	1.8×10^5-7.4×10^5	IIc_double-tip_data
	Double-tip (Ø = 0.25 mm)	Cavity	0.144	1.29	5.7×10^5	IIc_step_cavity_data
IId (pooled porous) θ = 26.6º, W = 0.52 m h = 10 cm, w = 3.1cm Po = 5%	Double-tip (Ø = 0.25 mm)	Step edges	0.073-0.250	0.82-1.85	2.9×10^5-9.9×10^5	IId_double-tip_data
IIIa (uniform flat) θ = 8.9º, W = 0.5 m h = 5 cm	Double-tip (Ø = 0.13 mm)	Step edges	0.054-0.234	1.35-3.55	2.2×10^5-9.3×10^5	IIIa_flat_steps
	Double-tip (Ø = 0.13 mm)	Cavity	0.152	2.66	6.0×10^5	IIIa_step_cavity_data
IIIb (pooled) θ = 8.9º, W = 0.5 m h = 5 cm, w = 5 cm	Double-tip (Ø = 0.13 mm)	Step edges	0.054-0.234	1.35-3.55	2.2×10^5-9.3×10^5	IIIb_pooled_steps
	Double-tip (Ø = 0.13 mm)	Cavity	0.152	2.66	6.0×10^5	IIIb_step_cavity_data
	Double-tip (Ø = 0.13 mm)	Step edges	0.054-0.234	1.35-3.55	2.2×10^5-9.3×10^5	IIIb_triple_decomposition
IIIc (flat/pooled) θ = 8.9º, W = 0.5 m h = 5 cm, w = 5 cm	Double-tip (Ø = 0.13 mm)	Step edges	0.054-0.234	1.35-3.55	2.2×10^5-9.3×10^5	IIIc_flat_pooled_steps
	Double-tip (Ø = 0.13 mm)	Step edges	0.078-0.234	1.70-3.55	3.1×10^5-9.3×10^5	IIIc_triple_decomposition

DA.2.1 Result files for double-tip conductivity probe experiments

For the experiments with a double-tip conductivity probe, a range of air-water flow properties was calculated and Table DA-6 lists the result file names and the contained air-water flow properties.

Table DA-6: Result files for double-tip conductivity probe; naming of result files and included air-water flow properties

File name(s)	Content / naming	Explanation of file content / naming
basics_summary	Position	Measurement position y###
	C-leading / C-trailing	Void fraction of leading / trailing tip of the 2-tip probe
	F-leading / F-trailing	Bubble count rate of leading / trailing tip of the 2-tip probe
chordlength_summary / chordtime_summary	y###	Measurement position followed by the bin classes for the chord length / time PDF
	f(a)	PDF for the air bubble chord length / time in %
	f(w)	PDF for the water droplet chord length / time in %
cluster_no_PDF cluster_no_PDF_constant_criterion_1mm cluster_no_PDF_wake_criterion	location: y###	Measurement position followed by the bin classes for the PDF of the number of particles in a cluster
	bubble_cluster	PDF of the number of bubbles per cluster in % (C < 0.3)
	droplet_cluster	PDF of the number of droplets per cluster in % (C > 0.7)
cluster_summary cluster_summary_constant_criterion_1mm cluster_summary_wake_criterion	No_in_cluster	Number of particles in cluster
	%_in_cluster	Percentage of particles in cluster
	No_of_clusters	Number of clusters
	cluster_per_s	Number of clusters per second
	ave_no_per_cluster	Number of particles per cluster
	ave_size_cluster	Average clustered chord size
	ave_rate_cluster_chord_size	Ratio of average clustered chord size to average chord size
	ratio_lead_ave	Ratio of lead particle size to average clustered chord size
interparticle_arrival_time_summary	y###	Measurement position followed by the bin classes for the inter-particle arrival time PDF
	#-#mm	Particle chord class in inter-particle arrival time analyses
	poission	Poisson distribution corresponding to particle data
Tu_V_summary	T0.5	Time for which the auto-correlation function equals 0.5
	T(Rxx=0)	Time at first crossing of x-axis (99 if no crossing)
	T(Min(Rxx))	Time for minimum auto-correlation value
	Min(Rxx)	Minimum auto-correlation value
	Txx	Auto-correlation time scale
	(Rxz)max	Maximum cross-correlation coefficient $(R_{xy})_{max}$
	T(Rxz)max	Time for maximum cross-correlation
	T(Rxz=0)	Time at first crossing of x-axis (98 if no crossing)
	T(Min(Rxz))	Time for minimum cross-correlation value
	Min(Rxz)	Minimum cross-correlation value
	T(0.5$(Rxz)_{max}$)	Time for half of maximum cross-correlation coefficient
	Txz	Cross-correlation time scale
	Tu	Turbulence intensity (97 if meaningless)
	V	Interfacial velocity
y###_autocor	Time	Time step for correlation analysis (1/sampling rate)
	Rxx	Auto-correlation function for leading tip of 2-tip probe
y###_crosscor	Rxy	Cross-correlation function for 2-tip probe
y###_interfaces	W->A leading W->A trailing	Position in raw signal for change of water to air phase for leading / trailing tip of 2-tip probe
	A->W leading A->W trailing	Position in raw signal for change of air to water phase for leading / trailing tip of 2-tip probe
y###_PDF_V	Bin-size	Bin classes for the PDF of the raw voltage signal
	V-leading / V-trailing	PDF of the raw voltage signals of leading / trailing tip of the 2-tip probe for single threshold analyses

DA.2.2 Result files for array of 2 single-tip conductivity probe experiments

For the experiments with an array of two single-tip conductivity probes, the air-water flow properties were calculated and Table DA-7 lists the result file names and the contained air-water flow properties.

Table DA-7: Result files for array of 2 singe-tip probes; naming of result files and air-water flow properties

File name(s)	Content / naming	Explanation of file content / naming
basics_summary	Position	Measurement position y###
	C-leading / C-trailing	Void fraction of the two single-tip probes
	F-leading / F-trailing	Bubble count rate of the two single-tip probes
chordtime_summary	y###	Measurement position followed by the bin classes for the chord time PDF
	f(a)	PDF for the air bubble chord time in %
	f(w)	PDF for the water droplet chord time in %
cluster_no_PDF cluster_no_PDF_constant_criterion_1mm cluster_no_PDF_wake_criterion	location: y###	Measurement position followed by the bin classes for the PDF of the number of particles in a cluster
	bubble_cluster	PDF of the number of bubbles per cluster in % ($C < 0.3$)
	droplet_cluster	PDF of the number of droplets per cluster in % ($C > 0.7$)
cluster_summary cluster_summary_constant_criterion_1mm cluster_summary_wake_criterion	No_in_cluster	Number of particles in cluster
	%_in_cluster	Percentage of particles in cluster
	No_of_clusters	Number of clusters
	cluster_per_s	Number of clusters per second
	ave_no_per_cluster	Number of particles per cluster
	ave_size_cluster	Average clustered chord size
	ave_rate_cluster_chord_size	Ratio of average clustered chord size to average chord size
	ratio_lead_ave	Ratio of lead particle size to average clustered chord size
interparticle_arrival_time_summary	y###	Measurement position followed by the bin classes for the inter-particle arrival time PDF
	#-#mm	Particle chord class in inter-particle arrival time analyses
	poission	Poisson distribution corresponding to particle data
Tu_V_summary	T0.5	Time for which the auto-correlation function equals 0.5
	T(Rxx=0)	Time at first crossing of x-axis (99 if no crossing)
	T(Min(Rxx))	Time for minimum auto-correlation value
	Min(Rxx)	Minimum auto-correlation value
	Txx	Auto-correlation time scale
	(Rxz)max	Maximum cross-correlation coefficient $(R_{xz})_{max}$
	T(Rxz)max	Time for maximum cross-correlation
	T(Rxz=0)	Time at first crossing of x-axis (98 if no crossing)
	T(Min(Rxz))	Time for minimum cross-correlation value
	Min(Rxz)	Minimum cross-correlation value
	$T(0.5(Rxz)_{max})$	Time for half of maximum cross-correlation coefficient
	Txz	Cross-correlation time scale
y###_autocor	Time	Time step for correlation analysis (1/sampling rate)
	Rxx	Auto-correlation function for single-tip probe in centreline
y###_crosscor	Rxy	Cross-correlation function between two single-tip probes
y###_interfaces	W->A leading W->A trailing	Position in raw signal for change of water to air phase for the two single-tip probes
	A->W leading A->W trailing	Position in raw signal for change of air to water phase for the two single-tip probes
y###_PDF_V	Bin-size	Bin classes for the PDF of the raw voltage signal
	V-leading / V-trailing	PDF of the raw voltage signals of the two single-tip probes for single threshold analyses

DA.2.3 Result files for triple decomposition analysis

The triple decomposition analysis provided some air-water flow properties for the raw signal and the decomposed signal components. Table DA-8 lists the result file names and the contained air-water flow properties.

Table DA-8: Result files for triple decomposition analysis; naming of result files and air-water flow properties

File name(s)	Content / naming	Explanation of file content / naming
basics_summary	Position	Measurement position y###
	C-leading / C-trailing	Void fraction of leading / trailing tip of the 2-tip probe
	F-leading / F-trailing	Bubble count rate of leading / trailing tip of the 2-tip probe
factors_crossproduct_fast_slow	Auto_factor	Factor of auto-correlation function between the slow and fast fluctuating components (factor χ in Eq. 2-21)
	Cross_slow_fast	Factor of cross-correlation function between the slow and fast fluctuating components (factor D in Eq. 2-22)
	Cross_fast_slow	Factor of cross-correlation function between the fast and slow fluctuating components (factor G in Eq. 2-22)
Tu_V_summary_high Tu_V_summary_mid Tu_V_summary_raw Tu_V_summary_sum_fast_slow_fluctuations	T0.5	Time for which the auto-correlation function equals 0.5
	T(Rxx=0)	Time at first crossing of x-axis (99 if no crossing)
	T(Min(Rxx))	Time for minimum auto-correlation value
	Min(Rxx)	Minimum auto-correlation value
	Txx	Auto-correlation time scale
	(Rxz)max	Maximum cross-correlation coefficient $(R_{xy})_{max}$
	T(Rxz)max	Time for maximum cross-correlation
	T(Rxz=0)	Time at first crossing of x-axis (98 if no crossing)
	T(Min(Rxz))	Time for minimum cross-correlation value
	Min(Rxz)	Minimum cross-correlation value
	$T(0.5(Rxz)_{max})$	Time for half of maximum cross-correlation coefficient
	Txz	Cross-correlation time scale
	Tu	Turbulence intensity (97 if meaningless)
	V	Interfacial velocity
	(Tu*V)	Velocity fluctuations
	Rxx_max	Maximum auto-correlation value for decomposed signals
	Rxx_fact	Factor of auto-correlation function (factors ϑ and ς respectively in Eq. 2-21)
	Rxz_fact	Factor of cross-correlation function (factors A and B respectively in Eq. 2-21)
y###_autocor_crossproduct_fast_slow_fluctuations	Time	Time step for correlation analysis (1/sampling rate)
	Rxx	Auto-correlation function for cross-product of slow and fast fluctuating signal components
y###_autocor_crossproduct_slow_fast_fluctuations	Rxx	Auto-correlation function for cross-product of fast and slow fluctuating signal components
y###_autocor_high / autocor_low / autocor_mid / autocor_raw	Rxx	Auto-correlation function for high pass, low pass, band pass signal components and raw signal
y###_autocor_sum_slow_fast_fluctuations	Rxx	Auto-correlation function of the sum of high pass and band pass signal components
y###_crosscor_crossproduct_fast_slow_fluctuations	Rxy	Cross-correlation function for cross-product of fast and slow fluctuating signal components
y###_crosscor_high / crosscor_low / crosscor_mid / crosscor_raw	Rxy	Cross-correlation function for high pass, low pass, band pass signal components and raw signal
y###_crosscor_sum_crossproduct_slow_fast_fluctuations	Rxy	Cross-correlation function for cross-product of slow and fast fluctuating signal components
y###_crosscor_sum_slow_fast_fluctuations	Rxy	Cross-correlation function of the sum of high pass and band pass signal components