

Time variability in rainfall events observed by PLUDIX

Abstract

Pludix is a rain gauge-disdrometer based on the analysis of an X-band Continuous Wave radar signal backscattered by hydrometeors. The Doppler shift of the individual falling particle, which is supposed to randomly cross the radar volume, is detected. The 2048 readings of the signal are inverted to generate a hydrometeor size distribution subdivided into 21 bands. Pludix operates integrating 60-sec. backscattered signal and so it provides a more detailed information with respect to the classical tipping bucket rain gauge. Moreover it's possible to detect the actual rainfall rate as an indirect product. Since September 1999 the instrument has been in operation aside with a tipping bucket and a weighting scale rain gauge downtown Bologna. More than 200 rainfall events have been detected and subgroup of 21 events has been investigated. The spectral intensity of the signal is analysed with different algorithms for both time variability and precipitation type.

A network of Pludix seems to be the right tool for investigating the space variability of rain in addition to time variability.

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General Description

Pludix (PLUviometer-Disdrometer X-band low power doppler radar) is a multifunctional instrument for monitoring and characterizing atmospheric precipitation on the ground with high sensitivity and fast response. Three different connections (direct RS232, modem and ethernet) grant remote connections to the central system. It can be operated automatically and has low maintenance requirements.



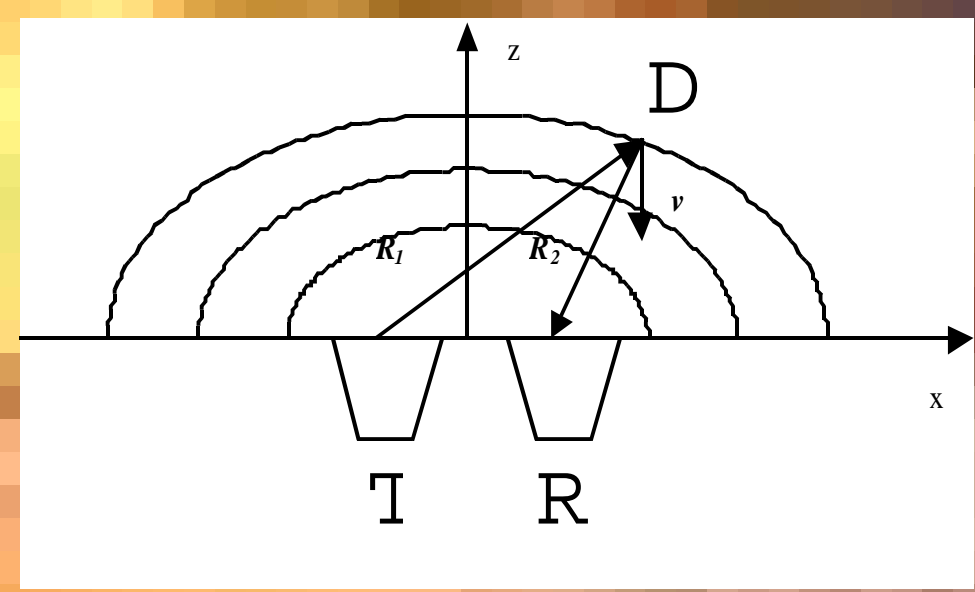
Determination of drop size distribution (from received CW signal)

The antenna diagram is both calculated and measured.

Radiation scattered in direction of R by the falling drop is amplified. R detects the doppler phase-shift which is function of droplet position, since it depends on the velocity component in the R_z direction.

The scattering diagram is calculated for a relatively large number of drop size classes using a T-Matrix code.

For each size class, instead of a narrow line at a given frequency, we have a bell-shaped signal. Due to the rain polydispersion the received signal is an envelop of bells with each size class contributing in relation with the distribution function.



For the inversion problem solution advantage is taken by known relationships and hypotheses:

- Gunn & Kinzer empirical law is used to connect fall velocity with drop size
- statistical hypothesis is made that droplets have equal probability of falling on horizontal surface above the instrument.

The inversion problem is reduced to inverting a square matrix.

As result of the inversion, a drop size distribution is determined.

Rainfall intensity, through drop concentration, is related to the intensity of the signal, accumulated in a given time interval (1 minute in our case).



Event classification

200 episodes have been recorded in the time period from February to May 2000.

A preliminary classification of selected groups has been performed using internal criteria since radar data were not available and synoptic situation too long to deal with for the many episodes.

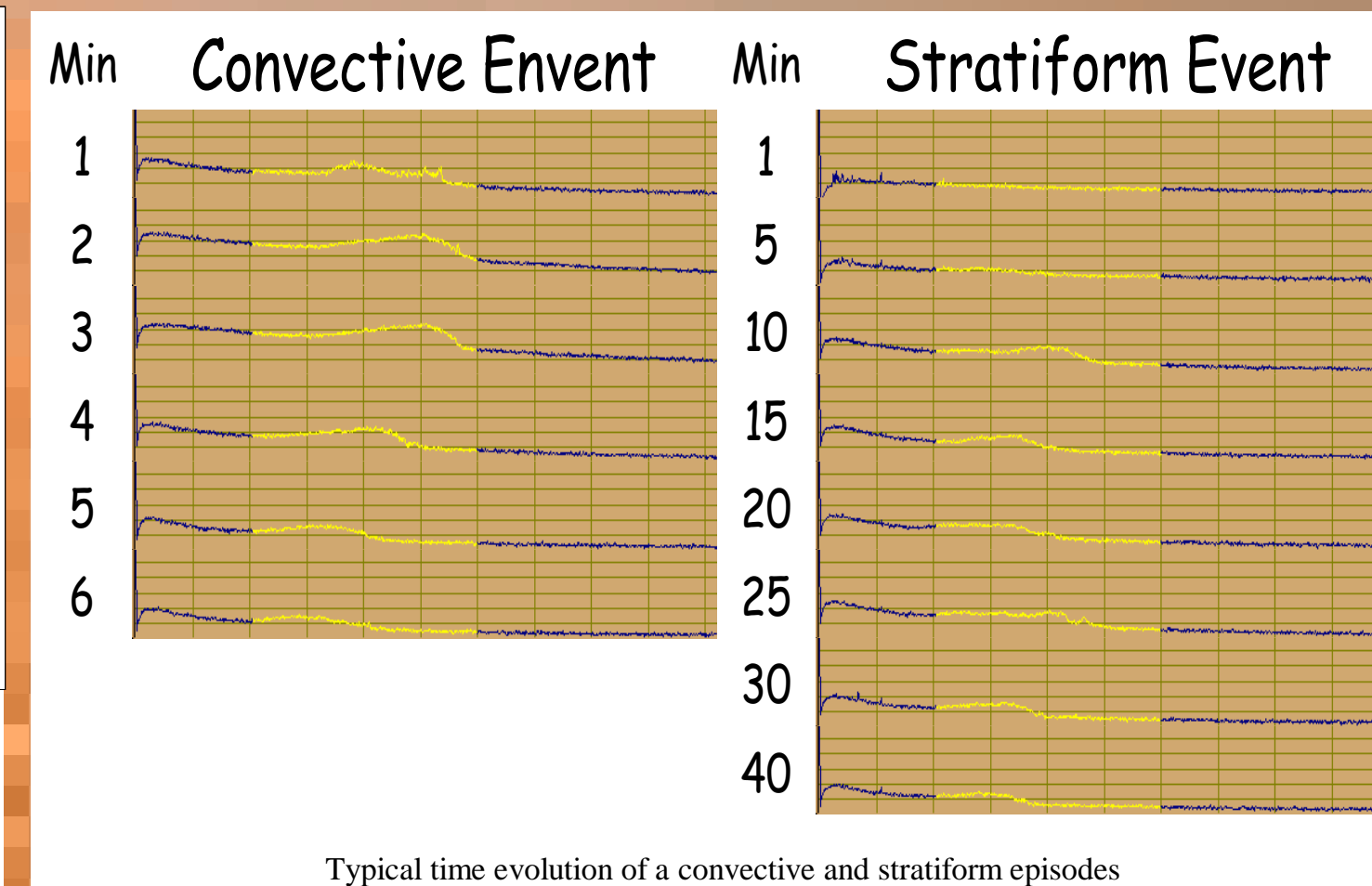
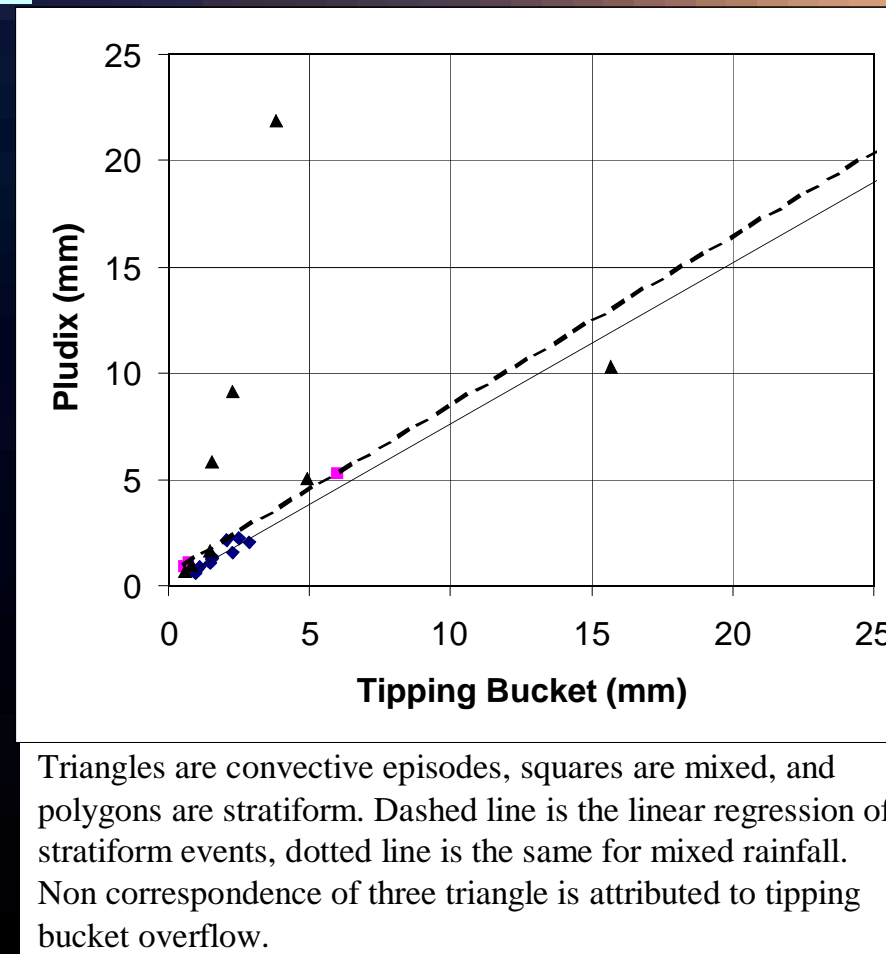
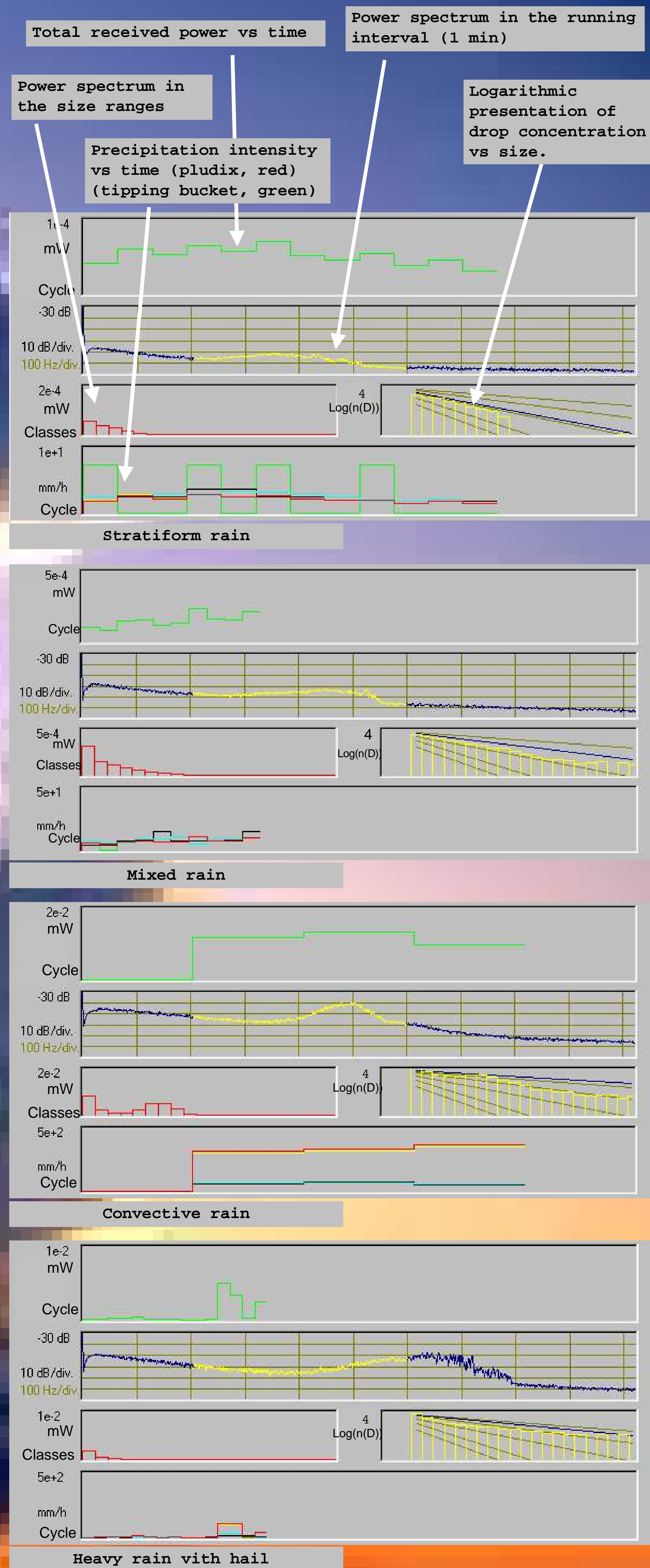
The four classes were:

- stratiform rain** (rain rate intensity less than 10 mm/h, total number of drops larger than 3.5 mm less than 10% total detected droplets);
 - convective rain** (rain rate greater than 10 mm/h);
 - mixed rain** (both previous criteria are satisfied during the event evolution);
 - heavy rain with hail** (presence of signal greater than -15dB and relative maximum in the hail zone).
- time evolutions of intensity and drop size distributions are investigated and discussed.

Stratiform events						
File name	Integrated tipping bucket	Integrated Pludix	Time length	$\max\left(\frac{dRR}{dt}\right)$ growing stage	$\min\left(\frac{dRR}{dt}\right)$ decreasing stage	
	mm	mm	min.	(mm/h)/min	(mm/h)/min	
20212	2.88	2.03	128	5	-5	
30117	2.04	2.10	107	3	-2.5	
32400	2.52	2.25	110	1	-1	
32910	1.56	1.29	58	2	-2	
40100	.96	.59	36	2	-2	
40300	1.44	1.11	33	1	-1	
40609	1.08	.85	21	3	-3	
40900	2.28	1.52	157	1	-1	
42400	1.56	1.33	24	7	-5	
50700	.84	.86	78	1	-1	

Mixed events						
File name	Integrated tipping bucket	Integrated Pludix	Time length	$\max\left(\frac{dRR}{dt}\right)$ growing stage	$\min\left(\frac{dRR}{dt}\right)$ decreasing stage	
	mm	mm	min.	(mm/h)/min	(mm/h)/min	
40200	.72	1.11	24	4	-4	
41700	.6	.91	14	5	-3	
42800	6.0	5.26	80	5	-5	

Convective events						
File name	Integrated tipping bucket	Integrated Pludix	Time length	$\max\left(\frac{dRR}{dt}\right)$ growing stage	$\min\left(\frac{dRR}{dt}\right)$ decreasing stage	
	mm	mm	min.	(mm/h)/min	(mm/h)/min	
30200	0.6	.70	6	15	-7.5	
32813	15.72	10.3	71	12	-20	
32900	1.44	1.62	11	20	-20	
41100	4.92	5.06	59	15	-12	
42900	.84	.93	17	15	-15	
50200	1.56	5.879	4	150	-50	
50214	3.84	21.88	7	300	-200	
51000	2.28	9.11	8	100	-50	



Conclusions

The examination of data from 200 events shows the capability of Pludix in evidencing the rainfall intensity and size distribution time evolution. This allows a characterisation of rain from different precipitating systems. Correlation between Pludix data and tipping bucket data is shown, with good correspondences for stratiform rain, mixed rain and part of convective episodes. Note that the latter deviates from the correct trend for the episodes in which the tipping bucket was in overflow. Because of the oddity of hail and snow events in Bologna, this study has been mostly limited to the rainfall detection. The same concepts are easily extended to any other type of hydrometeors (hail, graupel, snow etc.). At the moment, however, it's possible, even if the system is set to rain detection, to discriminate in real time an event with snow, hail, or rain, or events with mixed hydrometeors, making Pludix an automated "meteo sentinel". Finally, the system is particularly suitable for simultaneous control on large remote areas, letting the operator investigate space variability as well as time-variability of the event.

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PLUDIX patent number: MI 99A 001 906
 PLUDIX is manufactured jointly by ADA srl and NUBILA sas, Bologna. For orders or inquiries address to nubila@iol.it
<http://users.iol.it/nubila>
http://users.iol.it/plud_en.htm