SUPPLEMENTARY MATERIALS

This document provides supplementary information to the paper " Multiple characteristics of precipitation inferred from wind profiler radar Doppler spectra", doi: Pending.

The document is divided in several sections (S1, S2, etc.) containing Tables (S1.1, etc.) and Figures (Figure S1.1, etc.).

S1. File Header of the Degreane wind profiler PCL1300

This section briefly describes the binary file header of wind profiler model PCL1300 manufactured by Degreane, raw data file (.dat). For each variable (Code) a brief description and the byte location in the file header is listed.

Table S1.1. Header format of file PLC1300

Code	Description	Nº location	Code	Description	Nº location
NPAR	Parameters number in header	1	N_PIC	Number of peaks calculated	46
NWDREC	Total number of values (header plus data)	2	MOD_ST	1 for VHF, 0 for UHF	47
NHTS	Number height gates	3	PUIS_TX	Maximum potency from transmissor (in watts)	48
NRX	Number of beams	4	VERS_DATA	Format data version	49
NPTSP	Number of spectral points	5	FORMAT		50
NSPEC	Number of incoherent integrations	6	VERS_DSP	DSP program version	51
NCI	Number of coherent integrations	7	ALGO_DSP		52
IPP	Period between pulses	8	RECOUVREMENT	Spectral overlap	53
PW	Width of the pulse	9	PULSE_TX	Pulse duration	54
DLY1	Delay from system 1	10	PLUIE	Rain detection	55
SPAC1	Spacing from system 1	11	GAIN_ANT		56
NSAM1	Number of data system 1	12	TX_LOSS_ANT		57
DLY2	Delay from system 2	13	RX_LOSS_ANT		58
SPAC2	Spacing from system 2	14	RECMSEC	ms from measurement	59
NSAM2	Number of data system 2	15	CONCAT_LIMIT_VENT		60
RECYR	Year from record	16	CONCAT_LIMIT_SON		61
RECDAY	Day from record	17	NWDREC_HIGH		62
RECHR	Hour from record	18	NCI_SON		63
RECMIN	Minute from record	19	NCI_HARD		64

RECSEC	Second from record	20	NPTSP_SON	Number of point from spectrum	65
RECDAYMON	Day of the month from record	21	NSPEC_SON	Number of averaging	66
RECMON	Month from record	22	DCOPT_SON		67
DCOPT	Filter continue option	23	N_PIC_SON		68
WDOPT	Apodizing window	24	RECOUVREMENT_SON		69
AZ	Azimuth (in 0.1 degree)	25	FREQ_HIGH		70
FREQ	Frequency	26	RX_NF		71
BMCODE	Number of beam	27	ADC_BITS		72
ALT	Altitude from site (in m over MSL)	28	ADC_SCALE		73
EL	Elevation from beam (in 0.1 degree)	29	ADC_IMPENDANCE		74
SYS_DELAY1	Delay from system 1 in getting the band width (in nanoseconds)	30	TX_CURRENT	Current (in mA)	75
SYS_DELAY2	Delay from system 2 in getting the band width (in nanoseconds)	31	ATTENUATION	Attenuation in reception (in dB)	76
RECERR	Values wrong	32	ROSE_AURIA		77
CLOCK	Period in nanoseconds	33	VENT_AURIA		78
SITE		34	PLUIE_AURIA		79
LONGI	Grades from longitude	35	TEMP_AURIA		80
LONGI-M	Minutes from longitude	36	HUMID_AURIA		81
LONGI-S	Seconds from longitude	37	PRESSION_AURIA		82
LAT	Grades from latitude	38	WMO_BLOCK		83
LAT-M	Minutes from latitude	39	OWNER_COUNTRY		84
LAT-S	Seconds from latitude	40	OWNER_AGENCY		85
CODE_NBR		41	INSTRUMENT	Instrument type: the value 6 is for wind profiler	86
CODE_NBR_IPP		42	ANTENNA_TYPE	Antenna type (4 flat, 5 coco, 6 Yaggi, 7 Strip, 14 other, 15 missing	87
CODE_NBR_NOM		43	BEAMWIDTH	Width from beam (in 0.01 degrees)	88
CODE_NBR_LIGNE		44	STATION_TYPE	0 auto, 1 manned, 2 hybrid	89

DECODE_TRONC	45	

S2. Calculation of selected parameters contained in the Degreane file header

This section describes the calculation of selected parameters of the Degreane file header of the raw data files (.dat file).

The period of the wind profiler pulses is:

$$pp = Header[7] * Header[32] * 10^{-9} \tag{S1}$$

The pulse repetition frequency is:

$$f = \frac{1}{pp} \tag{S2}$$

The number of coherent integrations is obtained using three parameters from header

$$ncivrai = Header[6] \cdot Header[63] \cdot Header[41] \tag{S3}$$

The header provides the operating frequency:

$$F = \frac{Header[25]}{10} \tag{S4}$$

The unambiguous velocity is a function of the pulse repetition frequency, the frequency, and the number of coherent integrations :

$$V_u = \frac{f \cdot c}{4 \cdot ncivrai \cdot F} \tag{S5}$$

The velocity resolution is function of the number of spectral points.

$$dv = \frac{2 \cdot V_u}{Header[4]} \tag{S6}$$

To get the parameters in space (vertical values) is necessary to find the time pulse repetition:

$$Tprt1 = Header[9] \cdot Header[32] - Header[29] \tag{S7}$$

and the pulse width is::

$$Sprt1 = \frac{c}{2} \cdot [Tprt1 - Header[8] \cdot Header[32] * (Header[42] - 0.5)] \tag{8}$$

The spatial resolution is obtained from the header using the pulse width and its frequency

$$dh = \frac{c}{2}(Header[10] \cdot Header[32]) \tag{S9}$$

The maximum height is calculated using the number of height gates:

$$h_{max} = Sprt1 + (Header[2] - 1) \cdot dh \tag{S10}$$

After checking many files, we found that the value of *ncivrai* is not constant. In fact, this value sometimes changes in the same file between modes and beams. This change implies that the value of V_{amb} and *dv* change and it is not possible the comparison between files. This problem is solved if initially all files are checked and the minimum values of *ncivrai*, and its frequency associated, is chosen. Now the reference value from frequency and *ncivrai* is established and each file and each spectrum must be interpolated with these reference values.

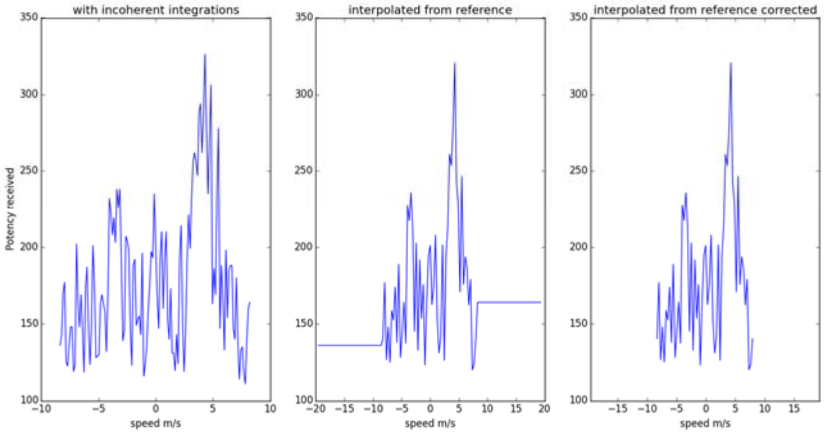

Figure S2.1. Resample the raw values for one height.

Notice that this resampling in speed axis sometimes lose precision, for example in the resampling change from a V_u of 8.35 m s^{-1} and *dv* of 0.13 m s^{-1} to V_u of 19.61 m s^{-1} and *dv* of 0.31 m s^{-1}. In addition, in this process is necessary to average to reach an averaged spectrum .

S3. Decoding of Degreane dat files

This section describes the decoding of the Degreane data files (.dat file). Each file contains one header for each operating mode, in this case there are two modes (high and low mode, depending on the maximum height recorded).

The header has a specific format (see **Table S1.1**) and the data values are stored after the header. These values are in binary format, composed by 2 bytes, and a half float conversion is needed to get the values. This conversion is based in little endian, so the first byte passes at the end. The conversion uses the first bit as the sign; the next 8 bits are the exponent and the rest the mantissa. This decoding process is commonly called bfloat16 floating-point format (see Figure S3.1 and S3.2).

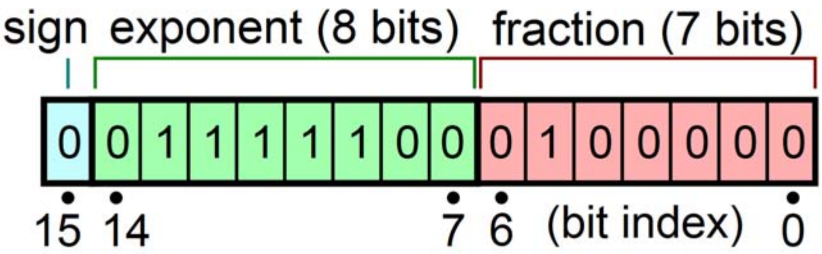

Figure S3.1. Format of data coding

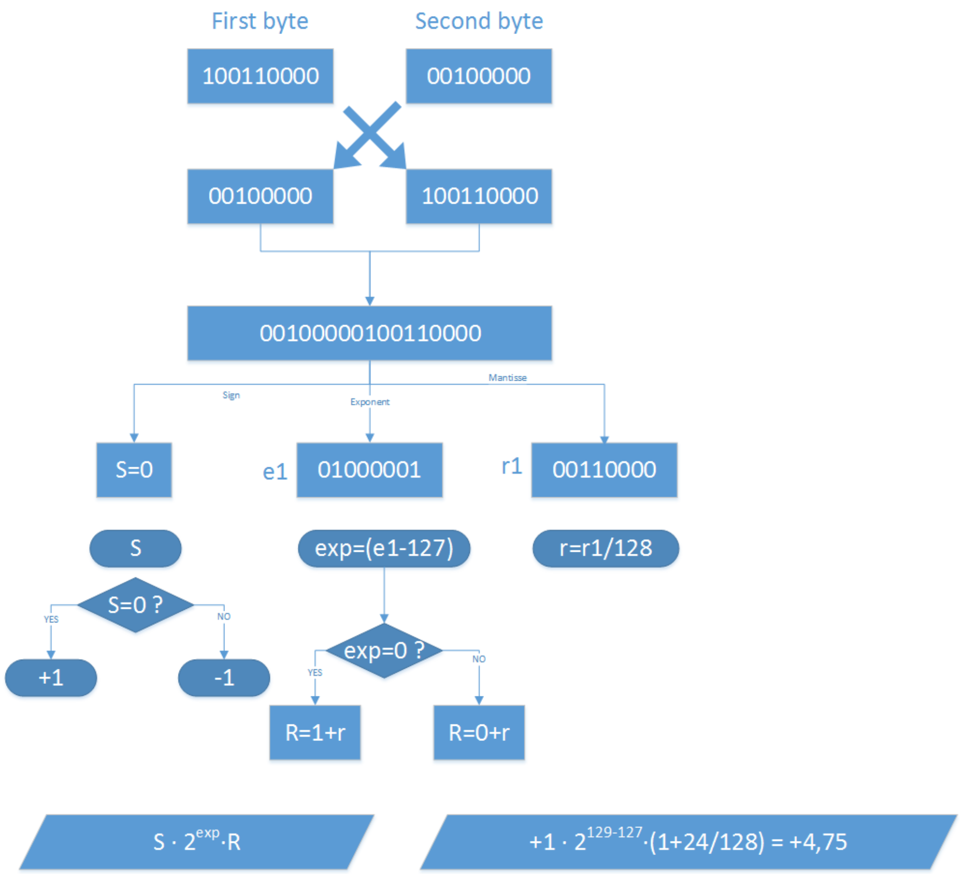

Figure S3.2. Half float conversion example.

S4. Overview of Radar Wind Profiler Doppler processing

This section provides a general description of the Radar Wind Profiler processing. The Doppler spectra on which we will work to obtain the meteorological signal are obtained by discrete Fourier transforms of the time series of the signal received at a given distance. They are composed of spectral lines describing the received power density as a function of the Doppler frequency spreading over the Nyquist interval or more simply converted into the radial velocity of the scatterers.

In the absence of an external signal, the spectral lines come from the thermal noise generated in the reception chain. This random noise is white, i.e. it spreads evenly over the entire spectrum. The first important step is to determine the average power of the noise lines. For this, the frequency interval is divided into several equal contiguous intervals. Usually the number of lines per interval is around 16. In this technique called the segment method it is hoped that there is at least one interval in which any external signal is absent. In each interval, the average power of the noise is calculated. The minimum value is then taken for the mean power of the noise.

In the ALWPP processing (Method1), an echo peak is defined when at least three consecutive spectral lines have powers greater than the average noise. Usually several type of peak can coexist in the spectra. The zero mean velocity ground clutter echo peak is still present. Non-zero speed spurious peaks can come from the detection of moving bodies such as birds, planes or cars. The radar receive also interference from transmitters at the same frequency. The peaks sought are those due to precipitation (Rayleigh scattering) and in clear air to refractive index fluctuations (Bragg scattering). These are not necessarily the most prominent peaks. The difficult task is to individualize all the peaks present, to reject the spurious peaks and to retain the relevant meteorological echo.

S5. Moments description

This section lists the formulas of the Doppler moments computed from the Doppler velocity spectrum recorded at each height, including the backscattered signal (moment of order 0), the radial velocity w (or another velocity component $v_{r,i}$) and the Spectral Width σ_r:

$$P_r = \int P_s^i \cdot dv, \quad \text{(S5.1.)}$$

$$v_r = \frac{1}{P_r}\int v_s^i \cdot P_s^i \cdot dv\,, \quad \text{(S5.2.)}$$

$$\sigma_r = \frac{1}{P_r}\int (v_s^i - v_r)^2 \cdot P_s^i \cdot dv\,, \quad \text{(S5.3)}$$

S6. Evaluation of additional events

This section complements the paper evaluation of period 24 to 25 March 2017 with the period covering 3 to 5 February 2017.

Figure S6.1 shows a comparison of MRR and UHF ALWPP and UBWPP processing of the vertical Doppler velocity. The overall patterns are very similar, being ALWPP a bit more sensitive than UPWPP.

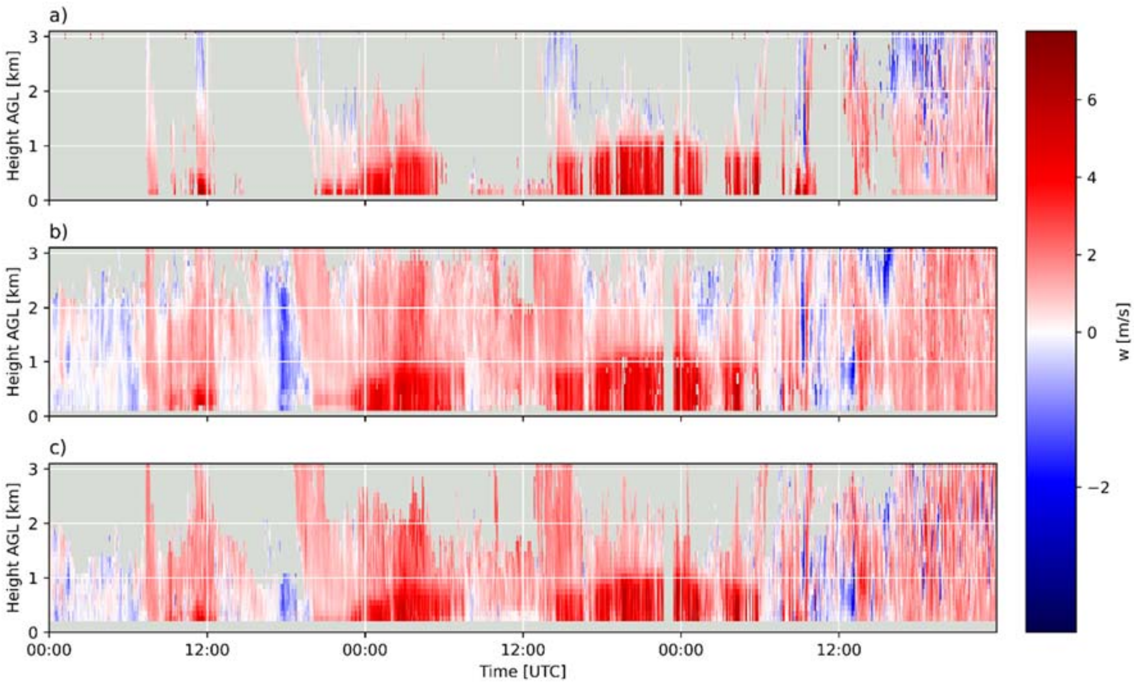

Figure S6.1. Comparison of vertical Doppler speed obtained with a). MRR, b). UHF wind profiler processed with ALWPP, and c). UHF wind profiler processed with UBWPP. Data recorded from 03/02/2017 to 05/02/2017**.**

Figure S6.2 and S6.3 compares zonal and meridional wind component computed with Method1 and Method2. Regarding the zonal wind (*u*), the mean error is -0.23 m/s and the variance 5.6 $(m/s)^2$ and for the latitudinal wind (*v*), the mean error is 0.50 m/s and the variance 4.87 $(m/s)^2$.

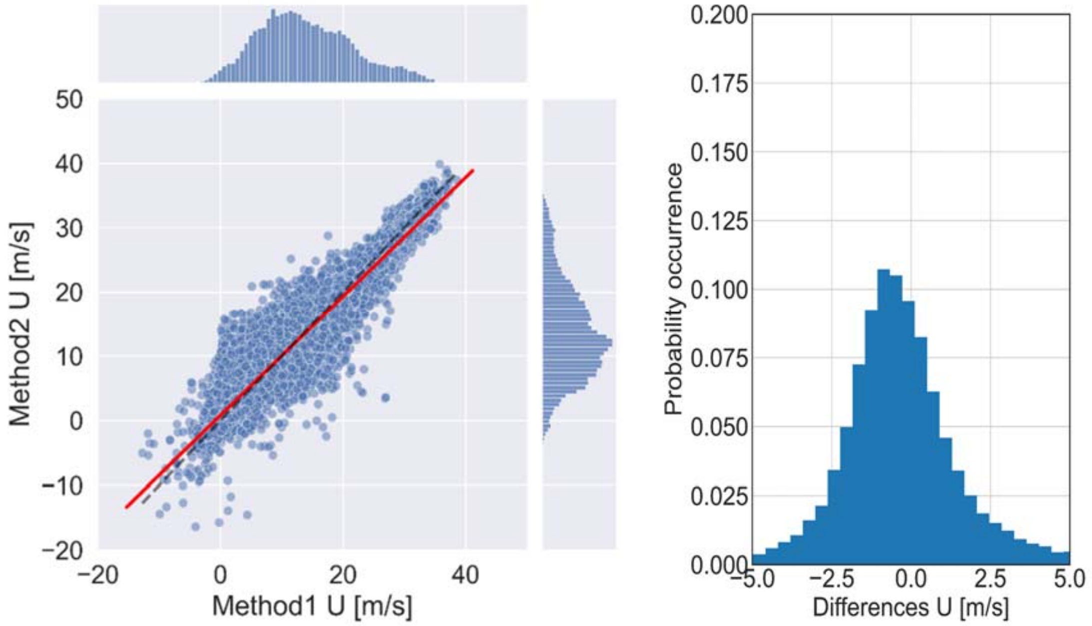

Figure S6.2. (left) Zonal wind comparison between Method1 and 2, (right) Distribution of the differences between Methods

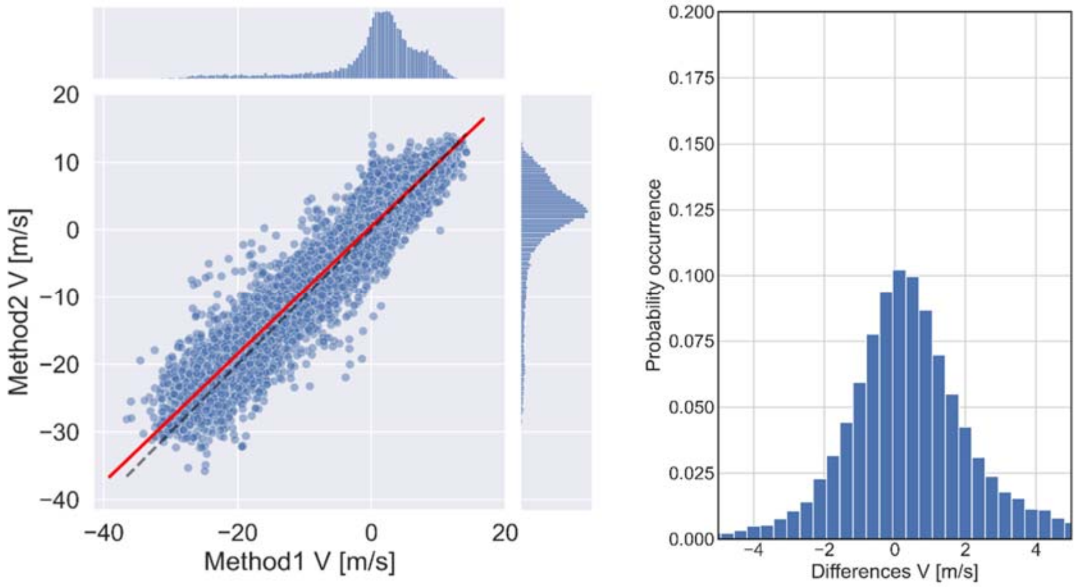

Figure S6.3. (left) Zonal wind comparison between Metheod1 and 2, (right) Distribution of the differences between Methods

Figure S6.4 shows the evolution of the vertical distribution of precipitation types for MRR and Method2 with A73. The overall patterns are similar, starting with snow at low level, then rain, and finally snow again.

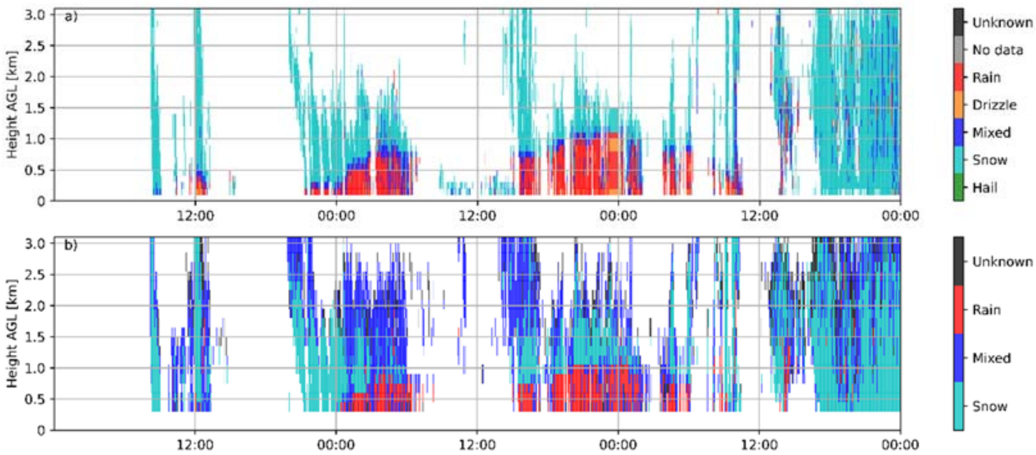

Figure S6.4. Comparison of hydrometeor classification obtained with a). MRR (considering 5 hydrometeor types) and b). UHF wind profiler (UBWPP) considering only 3 types. Data recorded from 03/02/2017 to 05/02/2017

S7. Additional information on 24 March 2017 event

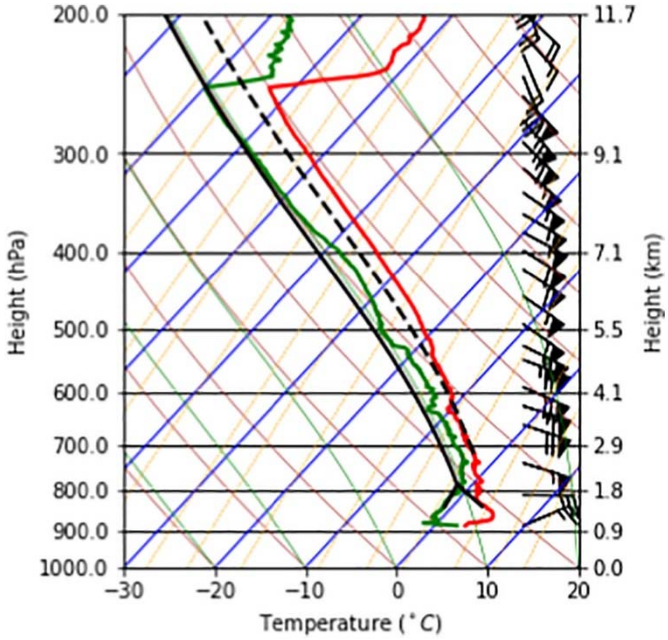

Figure S7.1. Sounding launched at LECD on 24 March 2017 at 22:34 UTC showing air temperature (red line), dew point (green line), vertical evolutions of an averaged air pàrcel with the features od the first 100 m (black continuos line) and vertical evolution of an air parcvel starting from the convective condensation level (black dash line). Source: Gonzalez et al. 202. doi:10.1016/j.atmosres.2021.105826