



*Supplement of*

## **Quantification of ice nuclei active at near 0 °C temperatures in low-altitude clouds at the Puy de Dôme atmospheric station**

**M. Joly et al.**

*Correspondence to:* M. Joly ([muriel.mourguy@univ-bpclermont.fr](mailto:muriel.mourguy@univ-bpclermont.fr)) and P. Amato ([pierre.amato@univ-bpclermont.fr](mailto:pierre.amato@univ-bpclermont.fr))

## Supporting Information to “Direct quantification of total and biological ice nuclei in cloud water” by Joly et al.

Table S1. pH and ion composition of the 12 cloud water samples studied.

Sample	pH	Concentration ( $\mu\text{M}$ )										
		$\text{Na}^+$	$\text{NH}_4^+$	$\text{K}^+$	$\text{Mg}^{2+}$	$\text{Ca}^{2+}$	$\text{Cl}^-$	$\text{NO}_3^-$	$\text{SO}_4^{2-}$	Acetate	Formate	Oxalate
# 76	5.9	n.a.	n.a.	n.a.	n.a.	n.a.	16.9	126.0	52.2	n.a.	n.a.	n.a.
# 77	6.0	124.8	408.5	22.8	26.8	148.5	12.8	47.9	19.6	58.3	109.6	12.3
# 78	5.5	22.7	32.7	9.2	12.3	7.1	24.1	10.4	7.1	3.3	11.3	3.0
# 79	4.6	0.6	52.7	1.6	0.8	3.2	0.3	5.0	1.3	4.3	5.6	1.0
# 80	4.9	80.6	39.3	6.1	12.0	5.2	13.3	2.2	1.8	7.4	5.3	1.1
# 81	5.8	145.7	188.6	6.2	20.3	9.3	23.4	11.2	4.8	15.3	15.6	6.7
# 82	5.3	1.0	75.4	0.1	0.9	6.1	0.2	2.0	1.6	4.2	6.2	3.0
# 83	5.6	93.5	531.1	10.7	14.3	34.6	12.2	49.9	10.7	b.d.l.	39.0	6.5
# 84	5.5	36.0	38.1	1.4	6.0	5.2	5.9	1.9	1.6	3.9	7.7	1.2
# 85	5.5	6.0	77.8	4.0	2.2	4.3	0.9	3.0	1.1	b.d.l.	18.2	3.3
# 86	5.9	8.8	16.8	5.5	1.3	4.5	1.0	1.0	0.5	3.2	3.2	1.0
# 87	6.2	21.2	39.3	7.6	8.3	2.3	26.7	10.9	5.3	4.0	13.6	0.7

n.a.: not available

b.d.l.: below detection limit.

Table S2. Spearman's correlation matrices (p-values, correlation coefficients and n) linking the different variables considered in our analysis. Positive relationships are indicated in green, negative relationships in red. Significant rank correlations (at 95% confidence) are indicated in bold/red.

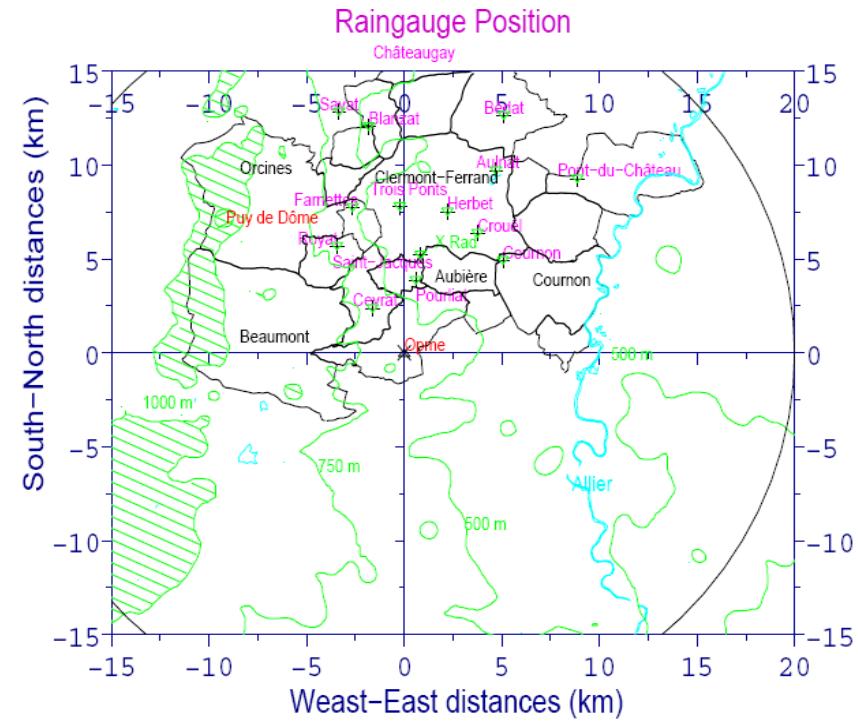
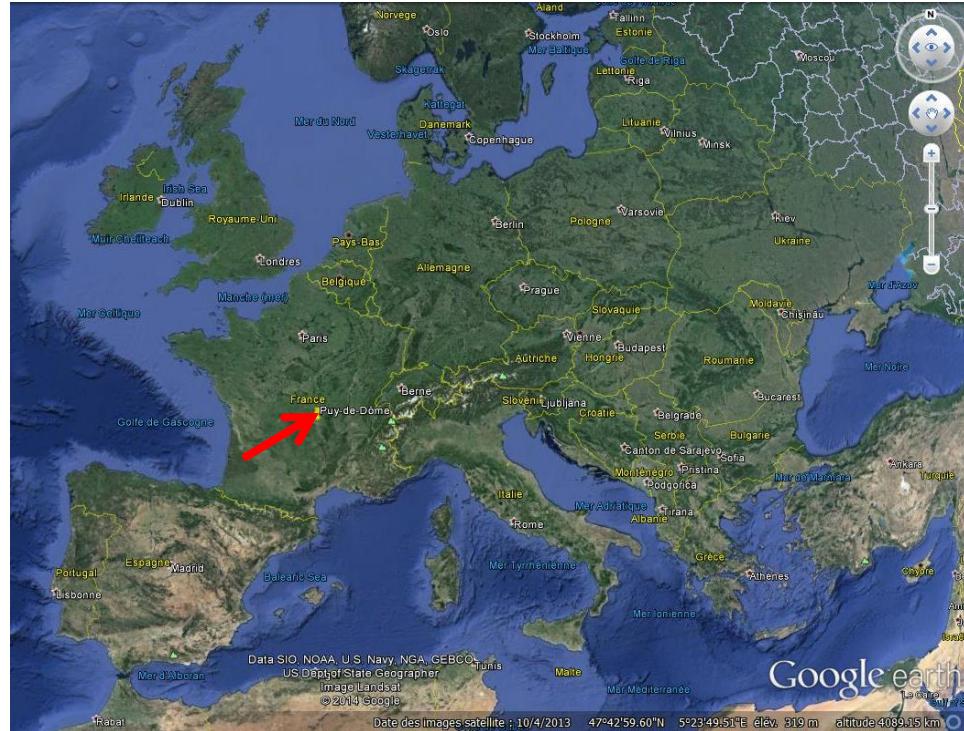
P-VALUES																																				
		Duration of sampling (h)	Sampling Temp. (°C)	Cumulated precipitation (mm)	Time in cloud before sampling (h)	Time in cloud after sampling (h)	Time event totale duration (h)	pH	Na <sup>+</sup> concentration (µM)	NH <sub>4</sub> <sup>+</sup> concentration (µM)	K <sup>+</sup> concentration (µM)	Mg <sup>2+</sup> concentration (µM)	Ca <sup>2+</sup> concentration (µM)	NO <sub>3</sub> <sup>-</sup> concentration (µM)	SO <sub>4</sub> <sup>2-</sup> concentration (µM)	Cl <sup>-</sup> concentration (µM)	Acetate concentration (µM)	Formate concentration (µM)	Oxalate concentration (µM)	Bact. Conc. (mL <sup>-1</sup> )	Onset temperature of freezing (°C)	Total IN concentration at -8°C (mL <sup>-1</sup> )	Total IN concentration at -9°C (mL <sup>-1</sup> )	Total IN concentration at -10°C (mL <sup>-1</sup> )	Total IN concentration at -11°C (mL <sup>-1</sup> )	Total IN concentration at -12°C (mL <sup>-1</sup> )	Bio IN concentration at -8°C (mL <sup>-1</sup> )	Bio IN concentration at -9°C (mL <sup>-1</sup> )	Bio IN concentration at -10°C (mL <sup>-1</sup> )	Bio IN concentration at -11°C (mL <sup>-1</sup> )	Bio IN concentration at -12°C (mL <sup>-1</sup> )	Proportion of biological IN at -8°C	Proportion of biological IN at -9°C	Proportion of biological IN at -10°C	Proportion of biological IN at -11°C	Proportion of biological IN at -12°C
Duration of sampling (h)		0.269	0.521	0.862	0.533	0.337	0.455	0.810	0.794	0.072	0.698	0.600	0.862	0.935	0.555	0.543	0.831	0.401	0.192	0.052	0.045	0.050	0.025	0.235	0.570	0.045	0.042	0.104	0.300	0.713	0.409	0.106	0.209	0.435	0.111	
Sampling Temp. (°C)			0.405	0.055	0.067	0.051	0.183	0.574	0.739	0.385	0.937	0.304	0.391	0.601	0.075	0.649	0.355	0.789	0.855	0.036	0.051	0.075	0.067	0.229	0.087	0.016	0.124	0.270	0.162	0.082	0.206	0.087	0.015	0.004	0.039	
Cumulated precipitation (mm)				0.026	0.015	0.004	0.265	0.758	0.747	0.426	0.933	0.351	0.288	0.307	0.557	0.889	1.000	0.715	0.845	0.785	0.599	0.343	0.506	0.358	0.696	0.946	0.355	0.498	0.358	0.665	0.314	0.398	0.975	0.740	0.862	
Time in cloud before sampling (h)					0.085	0.016	0.191	0.873	0.518	0.298	0.650	0.492	0.255	0.307	0.665	0.154	0.142	0.338	0.533	0.954	0.957	0.452	0.572	0.038	0.120	0.957	0.334	0.297	0.025	0.150	0.114	0.332	0.854	0.143	0.483	
Time in cloud after sampling (h)						0.000	0.075	0.272	0.640	0.790	0.467	0.527	0.572	0.888	0.471	0.811	0.750	0.936	0.855	0.360	0.282	0.513	0.360	0.701	0.712	0.282	0.488	0.277	0.726	0.829	0.495	0.201	0.758	0.372	0.528	
Time event totale duration (h)							0.100	0.332	0.615	0.545	0.582	0.703	0.505	0.974	0.429	0.491	0.669	0.979	0.868	0.413	0.314	0.675	0.465	0.676	0.674	0.314	0.666	0.457	0.701	0.777	0.265	0.118	0.782	0.372	0.461	
pH								0.212	0.640	0.043	0.117	0.649	0.159	0.194	0.101	0.863	0.102	0.572	0.162	0.407	0.591	0.559	0.535	0.829	0.464	0.591	0.627	0.719	0.777	0.603	0.685	0.252	0.782	0.332	0.461	
Na <sup>+</sup> concentration (µM)									0.252	0.023	0.000	0.012	0.077	0.017	0.035	0.311	0.110	0.052	0.117	0.702	0.097	0.236	0.307	0.385	0.242	0.097	0.166	0.032	0.313	0.194	0.117	0.548	0.651	0.898	0.705	
NH <sub>4</sub> <sup>+</sup> concentration (µM)										0.325	0.184	0.110	0.014	0.177	0.759	0.535	0.008	0.010	0.466	0.660	0.105	0.314	0.730	0.098	0.163	0.105	0.391	0.874	0.165	0.110	0.369	0.886	0.692	0.209	0.187	
K <sup>+</sup> concentration (µM)											0.001	0.102	0.003	0.002	0.013	0.790	0.047	0.221	0.004	0.295	0.883	0.879	0.867	0.912	0.326	0.883	0.906	0.510	0.810	0.250	0.770	0.024	0.156	0.394	0.280	
Mg <sup>2+</sup> concentration (µM)												0.010	0.011	0.001	0.011	0.392	0.023	0.028	0.029	0.810	0.368	0.538	0.531	0.410	0.091	0.368	0.471	0.111	0.270	0.059	0.223	0.290	0.304	0.618	0.542	
Ca <sup>2+</sup> concentration (µM)													0.124	0.024	0.582	0.473	0.113	0.001	0.614	0.175	0.035	0.019	0.021	0.077	0.080	0.035	0.024	0.011	0.068	0.082	0.369	0.693	0.602	0.323	0.305	
NO <sub>3</sub> <sup>-</sup> concentration (µM)														0.000	0.075	0.555	0.003	0.084	0.002	0.341	0.638	0.559	0.600	0.328	0.177	0.638	0.505	0.361	0.260	0.098	0.495	0.107	0.062	0.016	0.039	
SO <sub>4</sub> <sup>2-</sup> concentration (µM)															0.020	0.383	0.030	0.128	0.039	0.502	0.530	0.160	0.157	0.235	0.154	0.530	0.132	0.054	0.185	0.093	0.893	0.143	0.249	0.371	0.471	
Cl <sup>-</sup> concentration (µM)																0.545	0.385	0.926	0.013	0.112	0.538	0.655	0.968	0.777	0.637	0.538	0.819	0.483	0.987	0.580	0.334	0.016	0.081	0.459	0.506	
Acetate concentration (µM)																	0.947	0.658	0.544	0.501	0.600	0.786	0.775	0.810	1.000	0.600	0.839	0.867	0.912	0.644	0.222	0.775	0.345	0.789	0.280	
Formate concentration (µM)																		0.008	0.214	0.832	0.600	0.879	0.920	0.097	0.049	0.600	0.853	0.776	0.076	0.043	0.555	0.616	0.438	0.061	0.185	
Oxalate concentration (µM)																			0.750	0.357	0.092	0.145	0.216	0.001	0.002	0.092	0.164	0.173	0.001	0.003	0.221	0.877	1.000	0.881	0.797	
Bact. Conc. (mL <sup>-1</sup> )																				0.277	0.934	0.430	0.483	0.058	0.565	0.934	0.457	0.834	0.171	0.703	0.122	0.083	0.121	0.255	0.143	
Onset temperature of freezing (°C)																					0.002	0.018	0.022	0.609	0.676	0.002	0.026	0.124	0.749	0.517	0.558	0.029	0.000	0.033	0.011	
Total IN concentration at -8°C (mL <sup>-1</sup> )		</td																																		

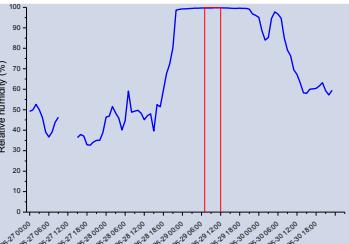
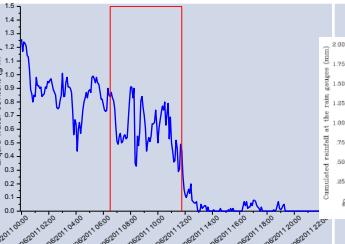
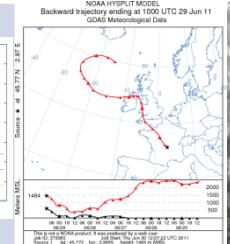
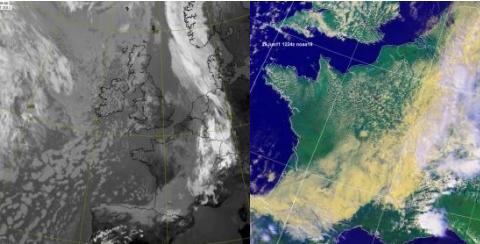
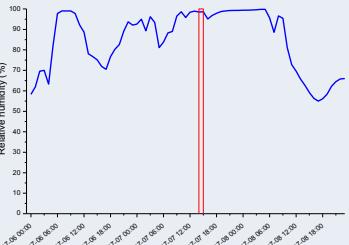
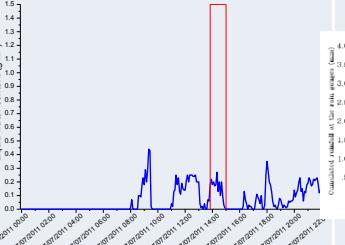
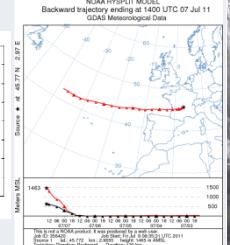
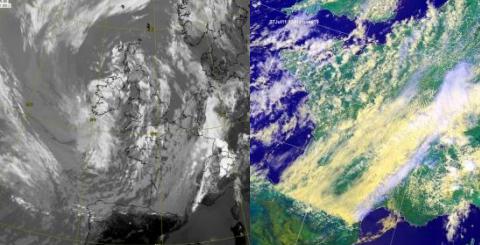
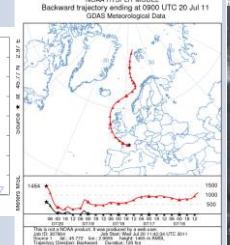
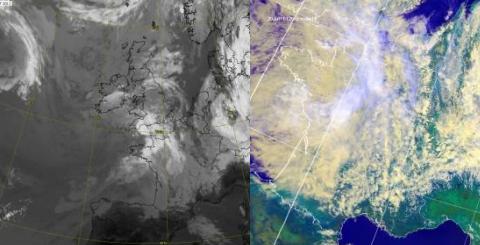
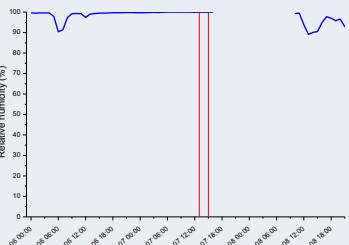
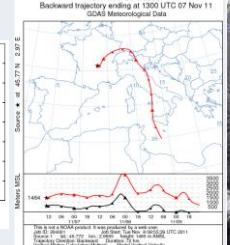
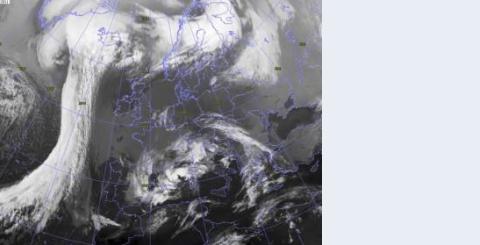
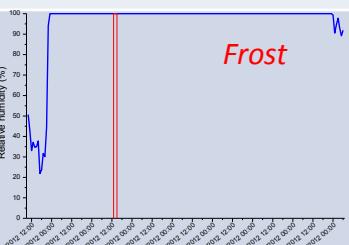
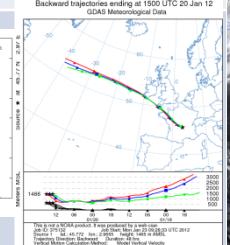
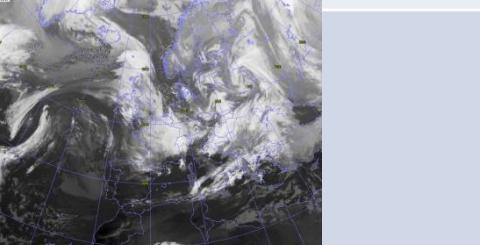


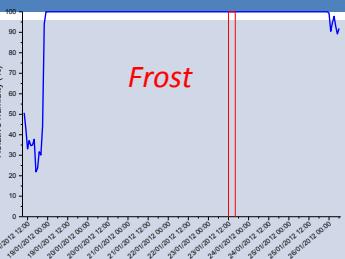
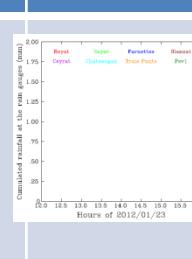
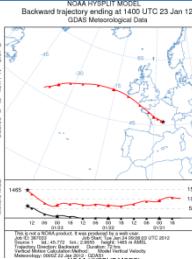
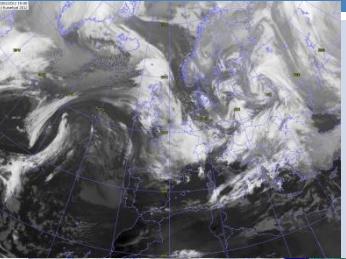
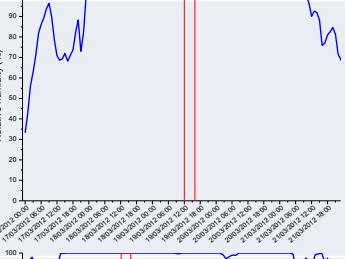
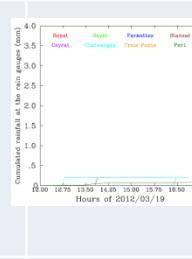
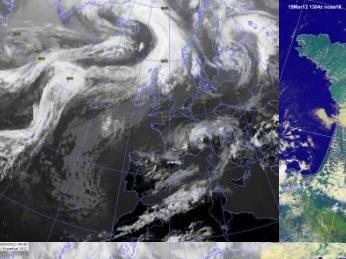
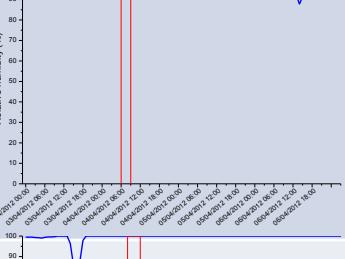
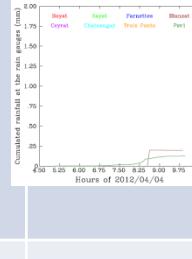
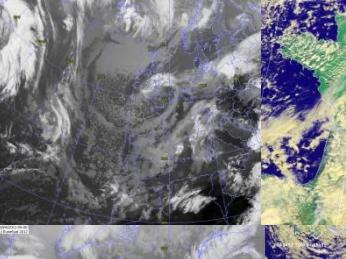
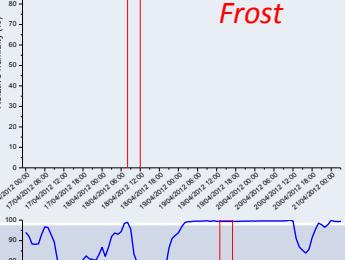
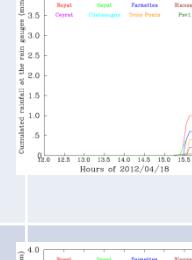
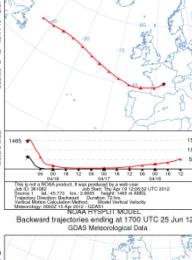
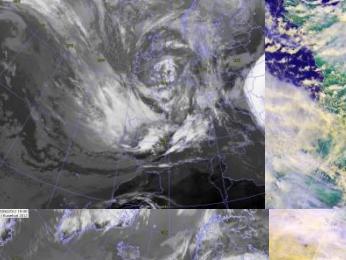
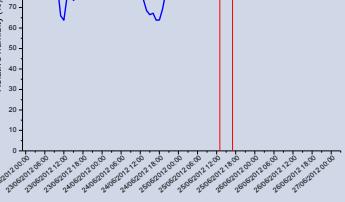
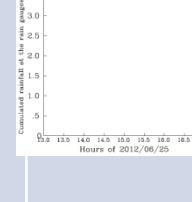
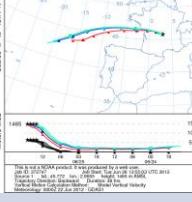


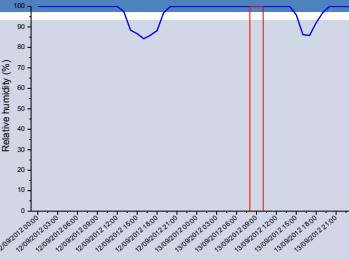
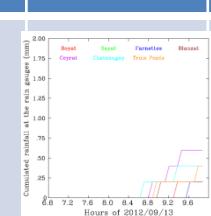
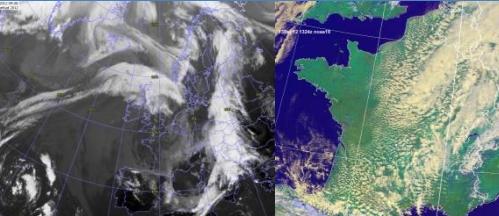
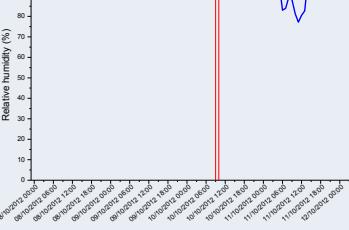
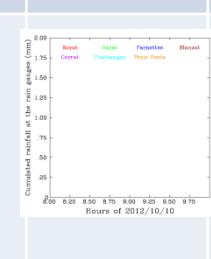
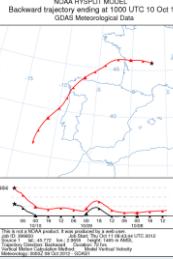
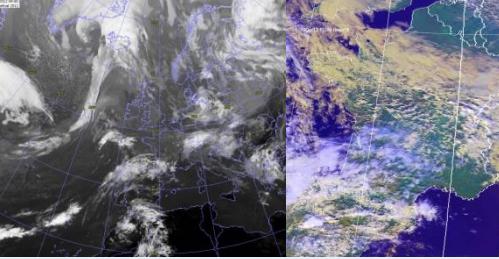
**Figure S1: A-** Maps locating (**left**) the sampling site (puy-de-Dôme Mountain, 45° 46' 20" North, 2° 57' 57" East) (Source: Google Earth) and (**right**) the rain gauge sites around puy-de-Dôme.

**B-** Table recapitulating meteorological data (relative humidity, LWC, downwind precipitation), backtrajectories and satellite visible images of each cloud event sampled. 72-hours backtrajectory plots were made using HYSPLIT model on GDAS1 meteorological data archive and default settings (Draxler and Rolph, 2010). Eumetsat satellite visible images were obtained from <http://www.woksat.info/wwp.html>.



Sample id.	Sampling date and time (UTC)	Relative Humidity (Sampling period framed in red)	Liquid Water Content (Sampling period framed in red)	Cumulated precipitation (mm)	HYSPLIT backtrajectory	EUMETSAT satellite visible images
#76	29 June 2011 6:30 AM – 11:45 AM					
#77	7 July 2011 1:50 PM – 3:00 PM					
#78	20 July 2011 7:30 AM – 9:10 AM		<p>Not Available (estimated 0.3 g m<sup>-3</sup> from sample collection rate and puy-de-Dôme data archive)</p>			
#79	7 Nov. 2011 1:00 PM – 2:30 PM		<p>Not Available (estimated 0.6 g m<sup>-3</sup> from sample collection rate and puy-de-Dôme data archive)</p>			
#80	20 Jan. 2012 12:45 PM – 3:00 PM		<p>Not Available (estimated 0.3 g m<sup>-3</sup> from sample collection rate and puy-de-Dôme data archive)</p>			

Sample id.	Sampling date and time (UTC)	Relative Humidity (Sampling period framed in red)	Liquid Water Content (Sampling period framed in red)	Cumulated precipitation (mm)	HYSPLIT backtracer trajectory	EUMETSAT satellite visible images
#81	23 Jan. 2012 1:00 PM – 4:00 PM		<b>Frost</b>  Not Available (estimated 0.1 g m⁻³ from sample collection rate and puy-de-Dôme data archive)			
#82	19 Mar. 2012 12:10 PM – 4:10 PM		 <b>Not Available</b> (estimated 0.1 g m⁻³ from sample collection rate and puy-de-Dôme data archive)			
#83	4 Apr. 2012 6:10 AM – 9:20 AM		 <b>Not Available</b> (estimated 0.1 g m⁻³ from sample collection rate and puy-de-Dôme data archive)			
#84	18 Apr. 2012 8:10 AM – 12:15 PM		 <b>Frost</b>  Not Available (estimated 0.1 g m⁻³ from sample collection rate and puy-de-Dôme data archive)			
#85	25 June 2012 1:35 PM – 5:00 PM		 <b>Frost</b>  Not Available (estimated 0.3 g m⁻³ from sample collection rate and puy-de-Dôme data archive)			

Sample id.	Sampling date and time (UTC)	Relative Humidity (Sampling period framed in red)	Liquid Water Content (Sampling period framed in red)	Cumulated precipitation (mm)	HYSPLIT backtracer trajectory	EUMETSAT satellite visible images
#86	13 Sep. 2012 7:50 AM – 9:50 AM		<b>Not Available</b> (estimated $0.1 \text{ g m}^{-3}$ from sample collection rate and puy-de-Dôme data archive)			
#87	10 Oct. 2012 8:40 AM – 9:50 AM		<b>Not Available</b> (estimated $0.1 \text{ g m}^{-3}$ from sample collection rate and puy-de-Dôme data archive)			

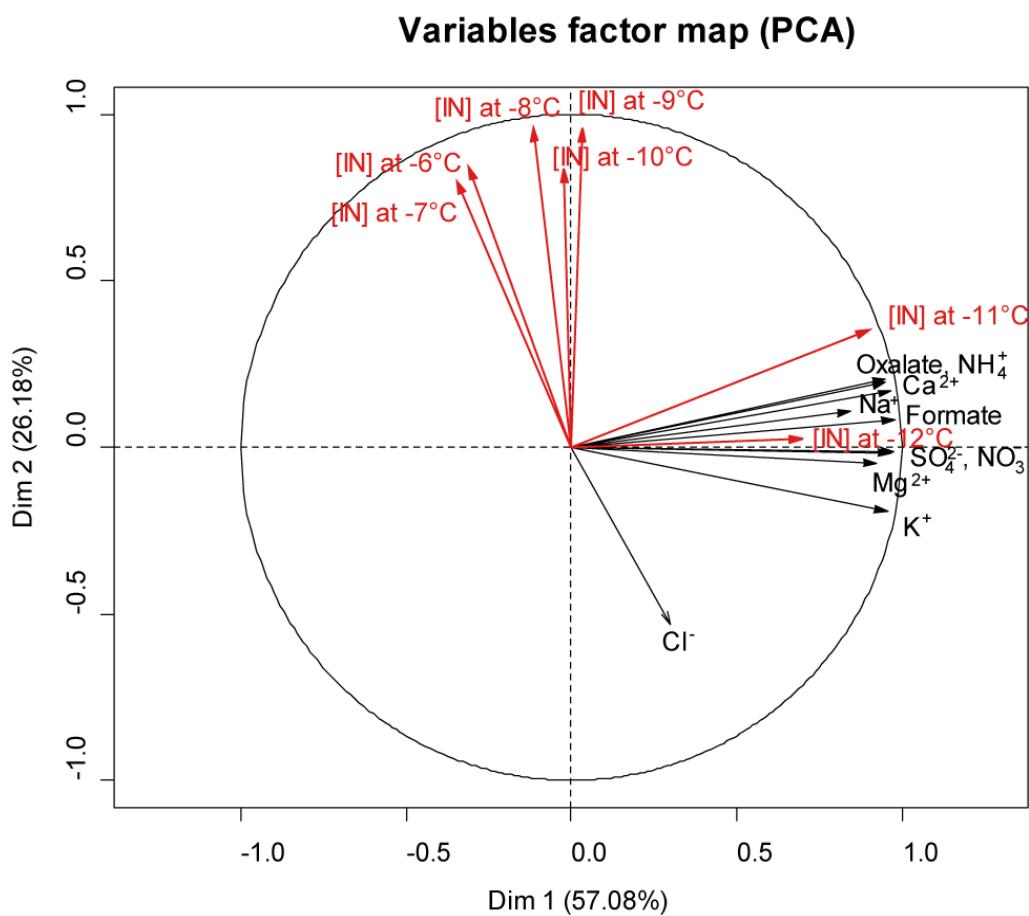


Figure S2. Principal component analysis (PCA) map of the chemical variables (black vectors) and of the concentrations of total IN measured at temperatures from -6°C to -12°C (red vectors). The analysis includes the samples for which all these data were available ( $n = 9$ ).