

IDENTIFICATION AND QUANTIFICATION OF GIANT BIOAEROSOL PARTICLES OVER THE AMAZON RAINFOREST

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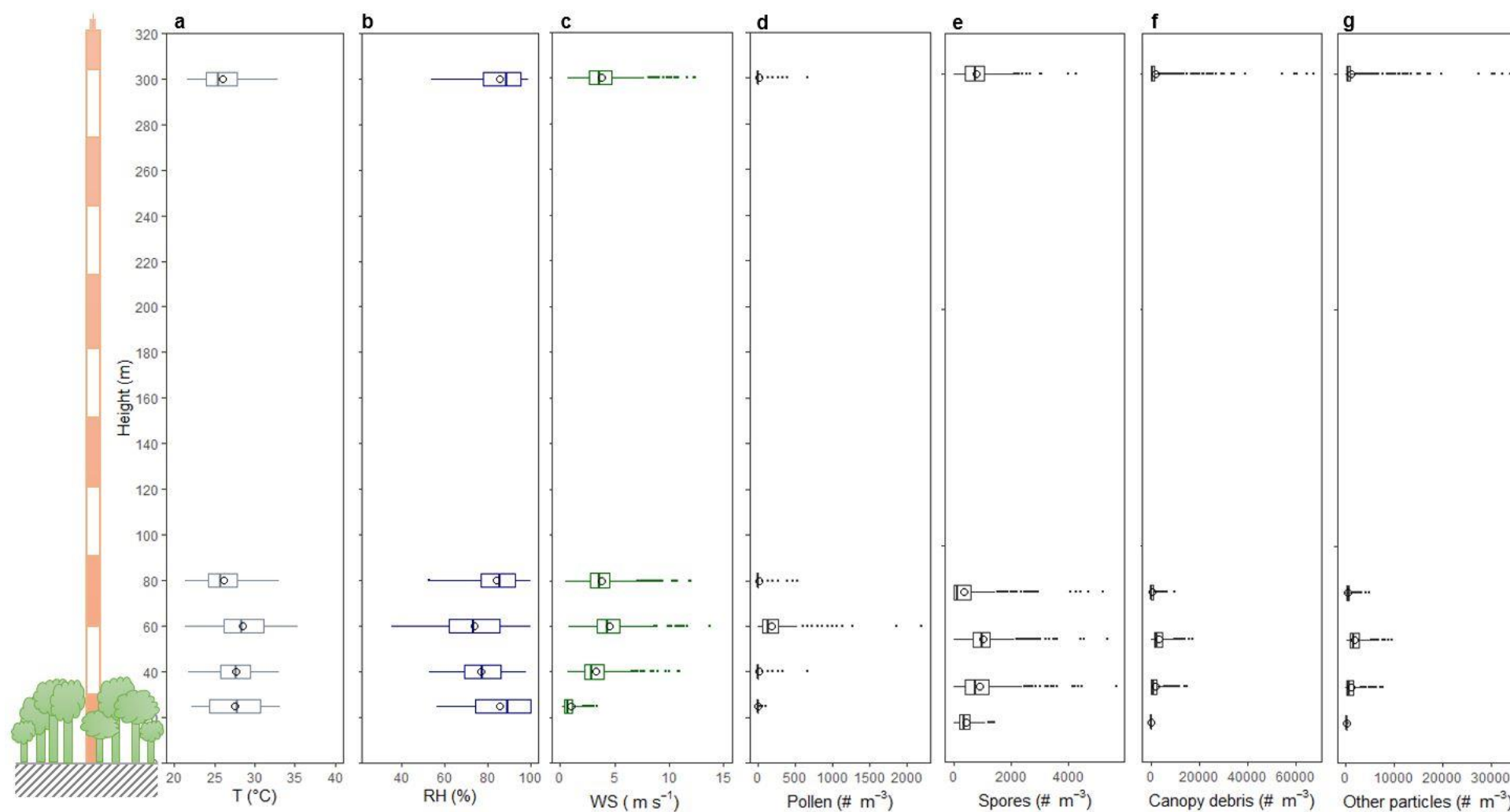
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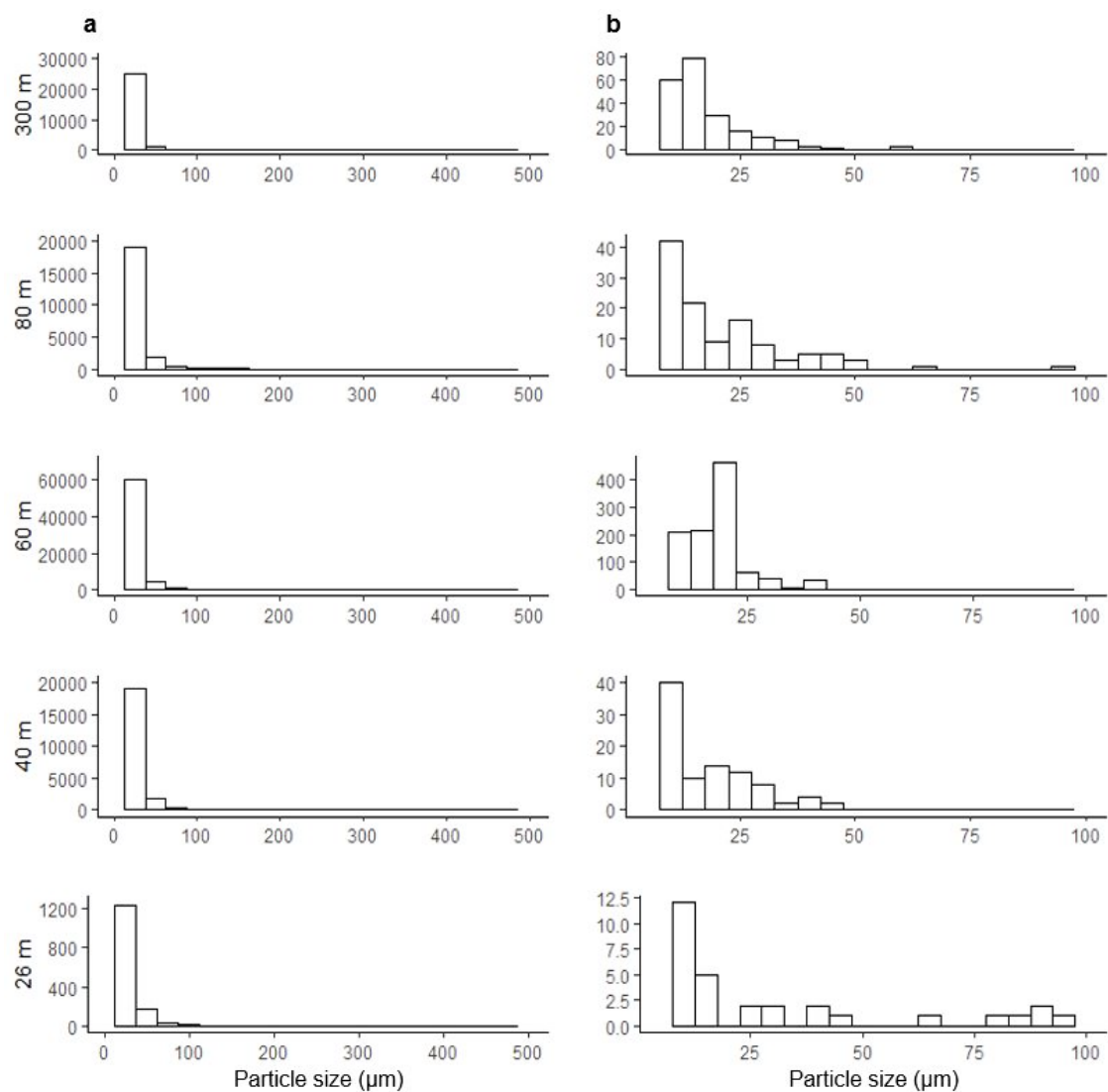
CONTENTS OF THIS FILE

Supplementary Figures 1 to 9

Supplementary Tables 1 to 2



Supplementary Figure 1 – Vertical concentration distribution of the main particles' category sampled at 26, 40, 60, 80 and 300 m, and meteorological parameters. a) Temperature ($^{\circ}\text{C}$); b) Relative humidity (%); c) Wind speed (m s^{-1}); d) Pollen, in number of particles per cubic meter of air ($\# \text{ m}^{-3}$); e) Spores: including fungal spores, yeasts, bryophyte spores and fern spores ($\# \text{ m}^{-3}$); f) Canopy debris: including leaf/wood pieces, plant waxes, leaf glands, leaf trichomes, insect fragments, hyphae sections ($\# \text{ m}^{-3}$); g) Other particles ($\# \text{ m}^{-3}$). Both seasons integrated. Boxplots with box bounds for the 1st and 3rd quartile, vertical line inside the box for the median value, while the circle marks the average, 5 and 95 percentiles as whiskers, and external dots show outliers. All data in 1h-resolution.



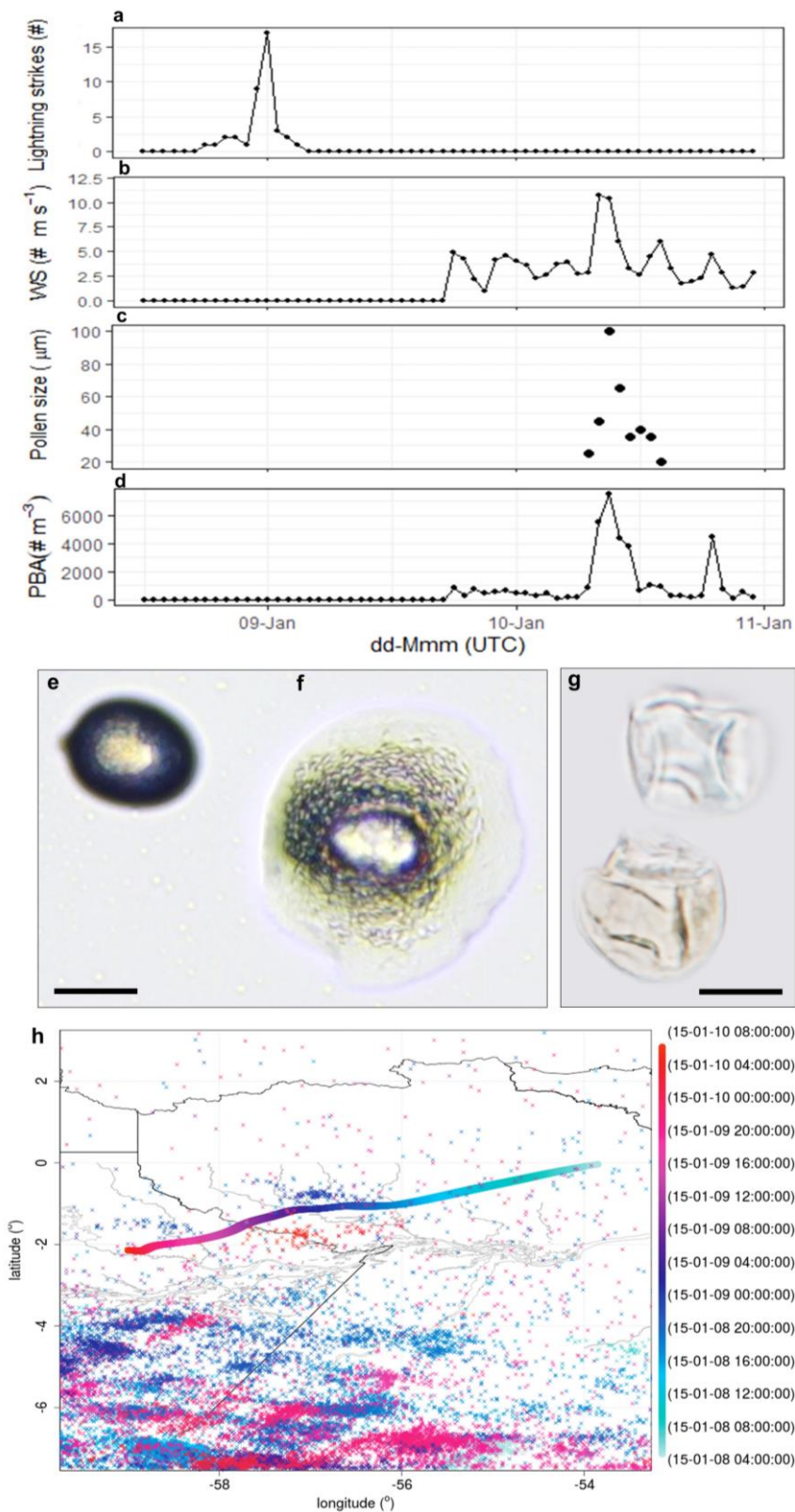
Supplementary Figure 2 - Size distribution (from 5 to 500 μm) of biological particles per height. Column (a) for total PBA particles sampled at each level; and Column (b) with pollen particles sampled at each level. The histograms display counts on vertical axis in logarithmic scale, and particle size on horizontal axis. Both seasons integrated for 26, 40 and 80 m; dry season for 60 m and wet season for 300 m.

Supplementary Table 1 – List of plant families per height of sampling, also presenting type of vegetation: T for canopy height tree, or B for bush/shrubs/grasses with medium or small length, average diameter of the sampled pollen grains, and relative abundance. Around 1/3 of the sampled grains were identified to family level and presented here in alphabetical order. The others were not identified at any level, and are listed as 'unidentified#'.

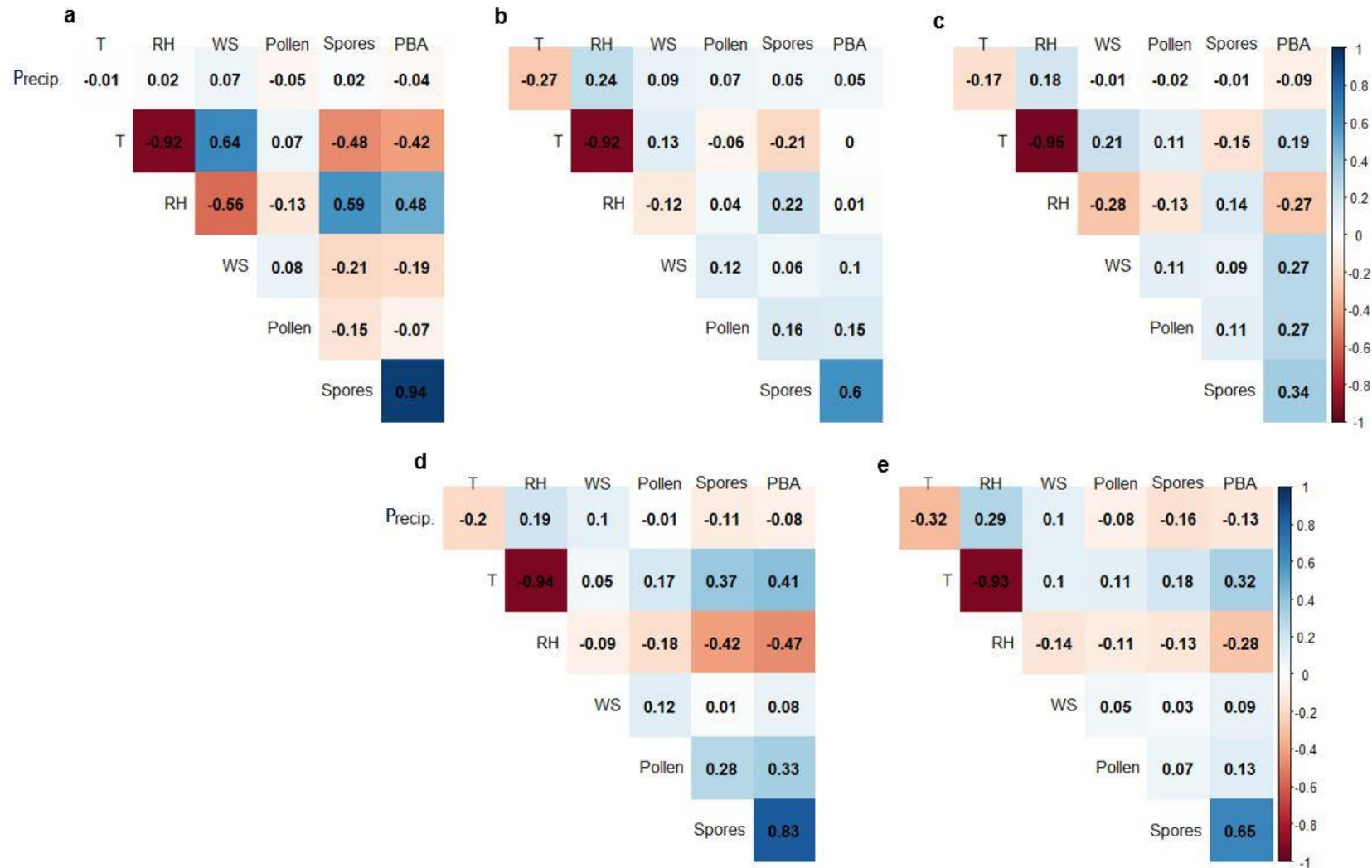
Family	Type	Average diameter	Height					Relative abundance
			26 m	40 m	60 m	80 m	300 m	
Amaranthaceae	B	20 µm		x	x	x	x	3.7%
Anacardiaceae	T	15 µm			x			2%
Arecaceae	T	20 µm	x		x	x		2.3%
Asteraceae	B	10 µm			x	x	x	8.5%
Bambusoideae ¹	B	40 µm				x		0.3%
Betulaceae	T	25 µm			x	x		0.5%
Caesalpinaceae	T	20 µm		x	x	x	x	2.4%
Combretaceae	T	25 µm	x	x	x			0.5%
Cyperaceae	B	35 µm		x	x	x	x	5.2%
Euphorbiaceae	T	15 µm		x	x		x	5.3%
Fabaceae	T	15 µm		x	x	x	x	7.2%
Fagaceae	T	15 µm			x			4.5%
Flacourtiaceae	T	20 µm			x			1.8%
Malpighiaceae	T	15 µm		x		x		0.2%
Meliaceae	T	20 µm			x	x	x	3.7%
Moraceae	T	10 µm	x	x	x	x	x	22.1%
Myricaceae	T	35 µm				x		0.3%
Myrtaceae	T	20 µm			x	x		3.6%
Oleaceae	T	20 µm					x	0.1%
Parianaceae	T	30 µm	x			x	x	0.4%
Poaceae	B	50 µm	x	x	x	x	x	0.4%
Podocarpaceae	T	100 µm	x		x	x	x	0.5%
Sapindaceae	T	20 µm				x		0.1%
Saxifragaceae	T	20 µm			x			0.5%
Simarubaceae	T	20 µm			x			0.5%
Unidentified #01	-	15 µm		x	x			0.2%
Unidentified #02	-	15 µm		x	x			1.3%
Unidentified #03	-	15 µm		x	x	x		1.2%
Unidentified #04	-	15 µm				x	x	0.3%
Unidentified #05	-	25 µm			x			0.8%
Unidentified #06	-	15 µm					x	0.5%
Unidentified #07	-	20 µm		x	x		x	1.1%
Unidentified #08	-	15 µm		x				0.1%
Unidentified #09	-	20 µm		x		x		0.1%
Unidentified #10	-	15 µm			x	x	x	0.9%
Unidentified #11	-	20 µm				x		0.1%
Unidentified #12	-	20 µm			x		x	1.0%
Unidentified #13	-	25 µm		x	x			0.3%
Unidentified #14	-	20 µm			x			0.5%
Unidentified #15	-	15 µm			x			0.6%
Unidentified #16	-	20 µm			x			0.3%

Family	Type	Average diameter	Height					Relative abundance
			26 m	40 m	60 m	80 m	300 m	
Unidentified #17	-	20 µm		x	x			0.6%
Unidentified #18	-	20 µm			x			0.5%
Unidentified #19	-	25 µm		x		x	x	0.2%
Unidentified #20	-	20 µm			x			0.5%
Unidentified #21	-	20 µm			x		x	0.9%
Unidentified #22	-	25 µm			x			0.5%
Unidentified #23	-	25 µm			x			0.5%
Unidentified #24	-	25 µm			x			0.5%
Unidentified #25	-	25 µm			x			0.2%
Unidentified #26	-	20 µm			x			0.5%
Unidentified #27	-	25 µm			x	x		0.5%
Unidentified #28	-	25 µm			x			0.6%
Unidentified #29	-	20 µm				x	x	0.5%
Unidentified #30	-	25 µm			x			0.3%
Unidentified #31	-	25 µm				x	x	0.1%
Unidentified #32	-	20 µm				x		0.1%
Unidentified #33	-	20 µm				x		0.2%
Unidentified #34	-	25 µm				x		0.1%
Unidentified #35	-	30 µm		x			x	0.3%
Unidentified #36	-	25 µm			x	x		0.5%
Unidentified #37	-	25 µm			x			0.5%
Unidentified #38	-	30 µm			x			0.2%
Unidentified #39	-	25 µm			x			0.5%
Unidentified #40	-	35 µm			x			0.3%
Unidentified #41	-	35 µm		x				0.1%
Unidentified #42	-	35 µm		x	x			0.5%
Unidentified #43	-	35 µm			x	x	x	0.6%
Unidentified #44	-	45 µm		x		x	x	0.3%
Unidentified #45	-	45 µm			x	x		0.5%
Unidentified #46	-	40 µm				x		0.1%
Unidentified #47	-	30 µm			x			0.2%
Unidentified #48	-	60 µm			x	x	x	0.2%
Unidentified #49	-	65 µm				x		0.1%
Unidentified #50	-	40 µm				x		0.1%
Unidentified #51	-	35 µm				x		0.2%
Unidentified #52	-	40 µm			x			0.5%
Unidentified #53	-	40 µm			x			0.5%
Unidentified #54	-	30 µm		x				0.3%
Unidentified #55	-	40 µm			x	x		0.3%

¹Bambusoideae is a subfamily of Poaceae, and was considered separated here to highlight the diversity.



Supplementary Figure 3 – Example of ruptured pollen collected during the wet season after a thunderstorm event with intense lightning strikes: (a) Number of lightning strikes that hit the sampling site 24 h previous to the sampling; (b) Wind speed (m s^{-1}) for the presented period; (c) Size of pollen particles sampled: they occurred only during the event, no pollen grains were sampled on the 24 h prior of after the particle peak; (d) Coarse PBA concentration at 80 m height ($\# \text{ m}^{-3}$) peaking 30 h after the passage of a thunderstorm; (e) Intact Poaceae pollen, scale bar: 20 μm ; (f) Ruptured Poaceae pollen after submitted to an electric field with subparticle content still around the empty shell in a high humidity atmosphere (95% RH); (g) Empty pollen shells collected at 80 m after a thunderstorm, scale bar: 20 μm ; (h) Air mass backtrajectories 72 h prior to the sampling of the ruptured pollen, with a colored line showing the mass trajectory, and each dot representing a lightning strike during the period (for each date and time displayed on the right side).

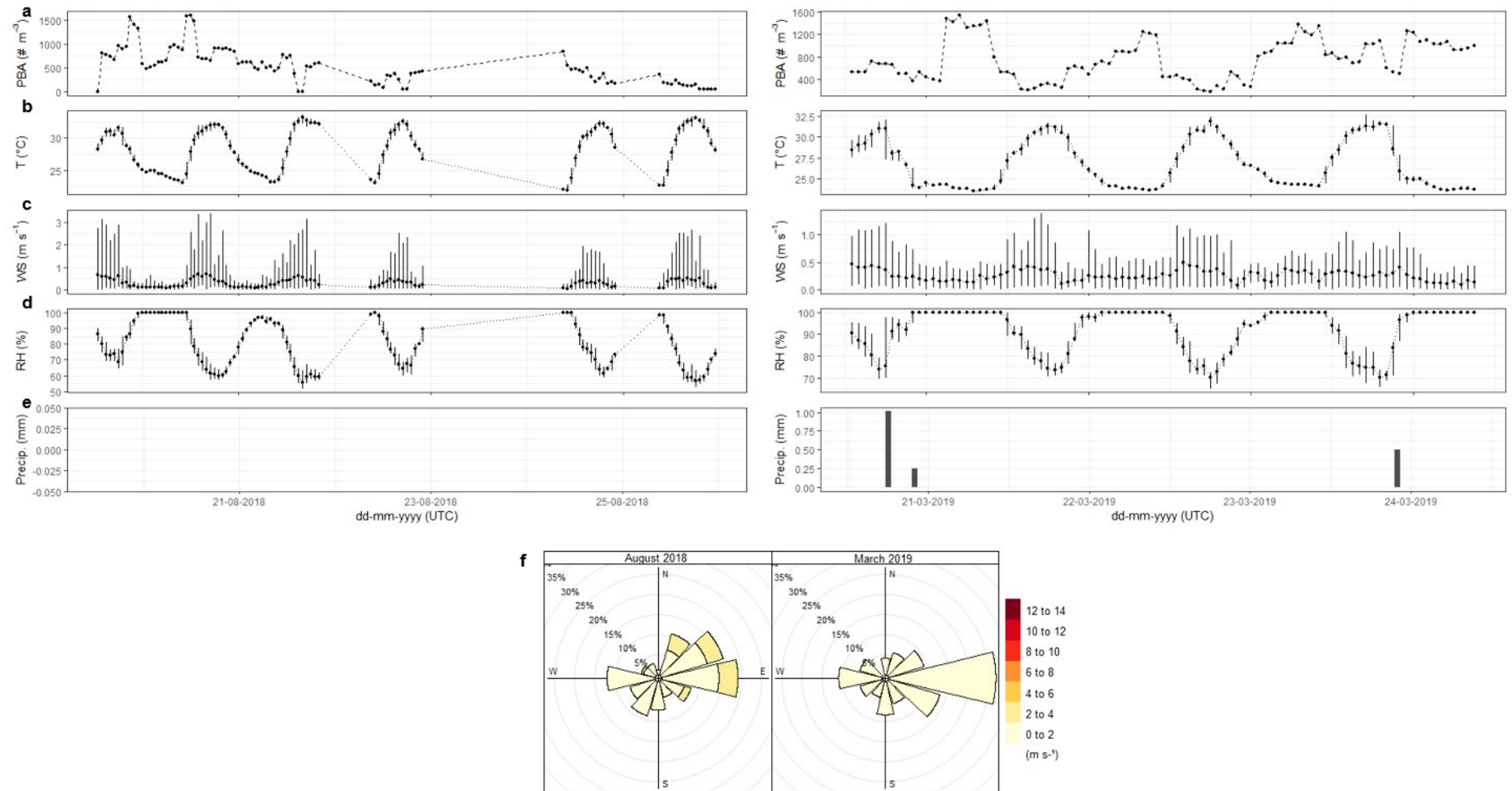


Supplementary Figure 4 – Correlation overview of meteorological parameters and biological particle distribution. Spearman coefficients (ρ) in each internal square filled with a gradual color scale from red (negative correlation) to blue (positive correlation) per height: a) 26 m; b) 40 m; c) 60 m; d) 80 m; e) 300 m. Presenting values for Precipitation, Temperature (T), Relative Humidity (RH), Wind speed (WS), Pollen particles, Spores (all categories) and all sampled biological particles (PBA). Scale from -0.3 to +0.3 shows weak correlation, -0.3 to -0.6 and +0.3 to +0.6 a moderate correlation, -0.7 to -1 and +0.7 to +1 a strong correlation. Significance level of 99%.

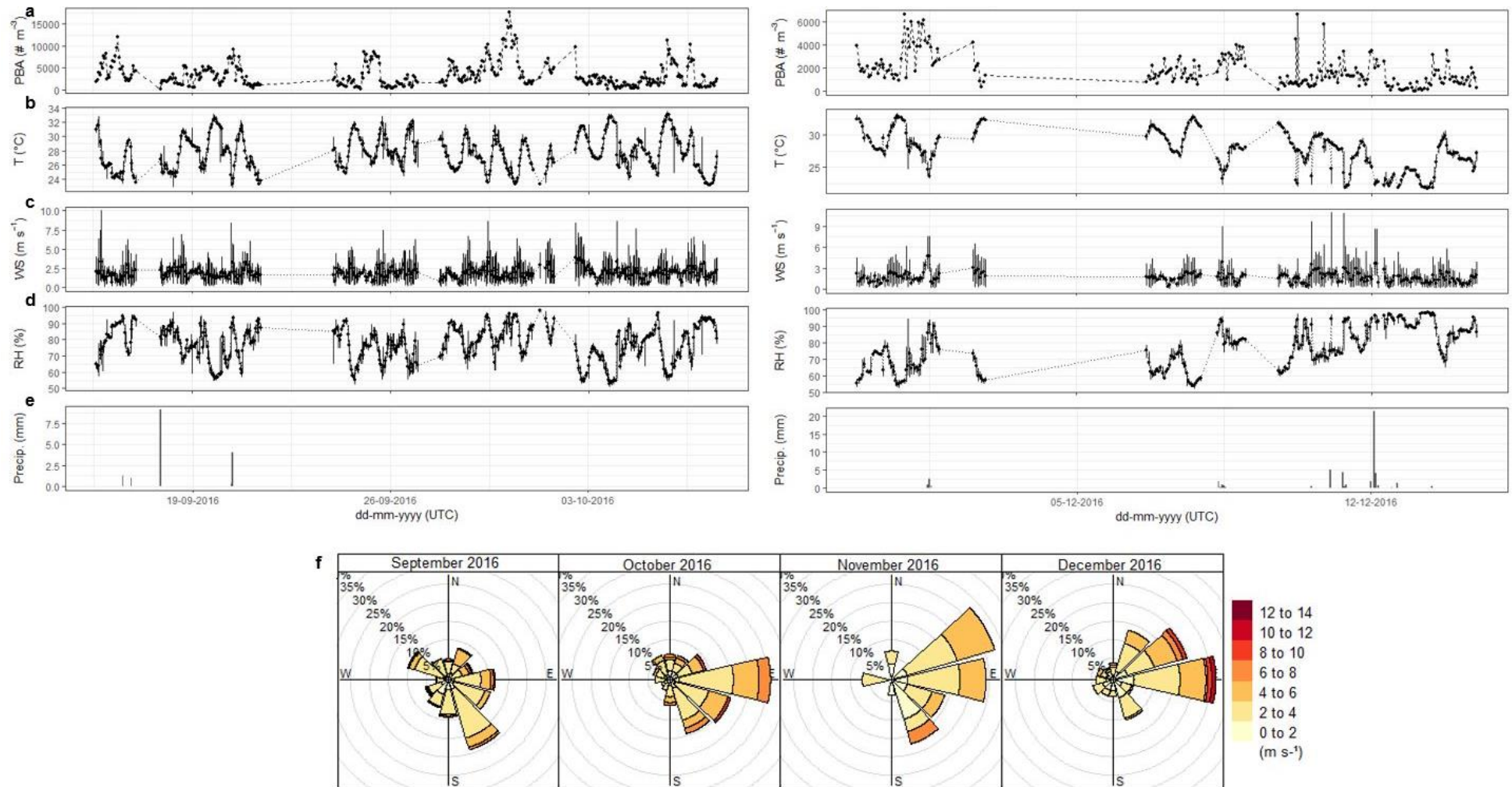
Supplementary Table 2 – Statistical results from Mann-Whitney U test to evaluate median and distribution similarities. Panel (a) shows p-values of the Mann-Whitney test for day and night periods against Pollen, Spores and PBA distributions for 26, 40, 60, 80 and 300 m height; (b) presents p-values for wet and dry seasons for the same biological particles for 26, 40 and 80 m levels. Level of significance of 99%, with statistical difference ($p \leq 0.01$) for Spores and PBA considering the concentrations for the day and night periods; and also, for all biological categories regarding the seasons wet and dry.

a			
p-values for day/night periods			
	Spores	Pollen	PBA
26 m	< 0.001	0.03	< 0.001
40 m	0.7	0.7	0.8
60 m	0.09	0.06	0.8
80 m	0.09	0.2	0.05
300 m	0.04	0.8	0.09

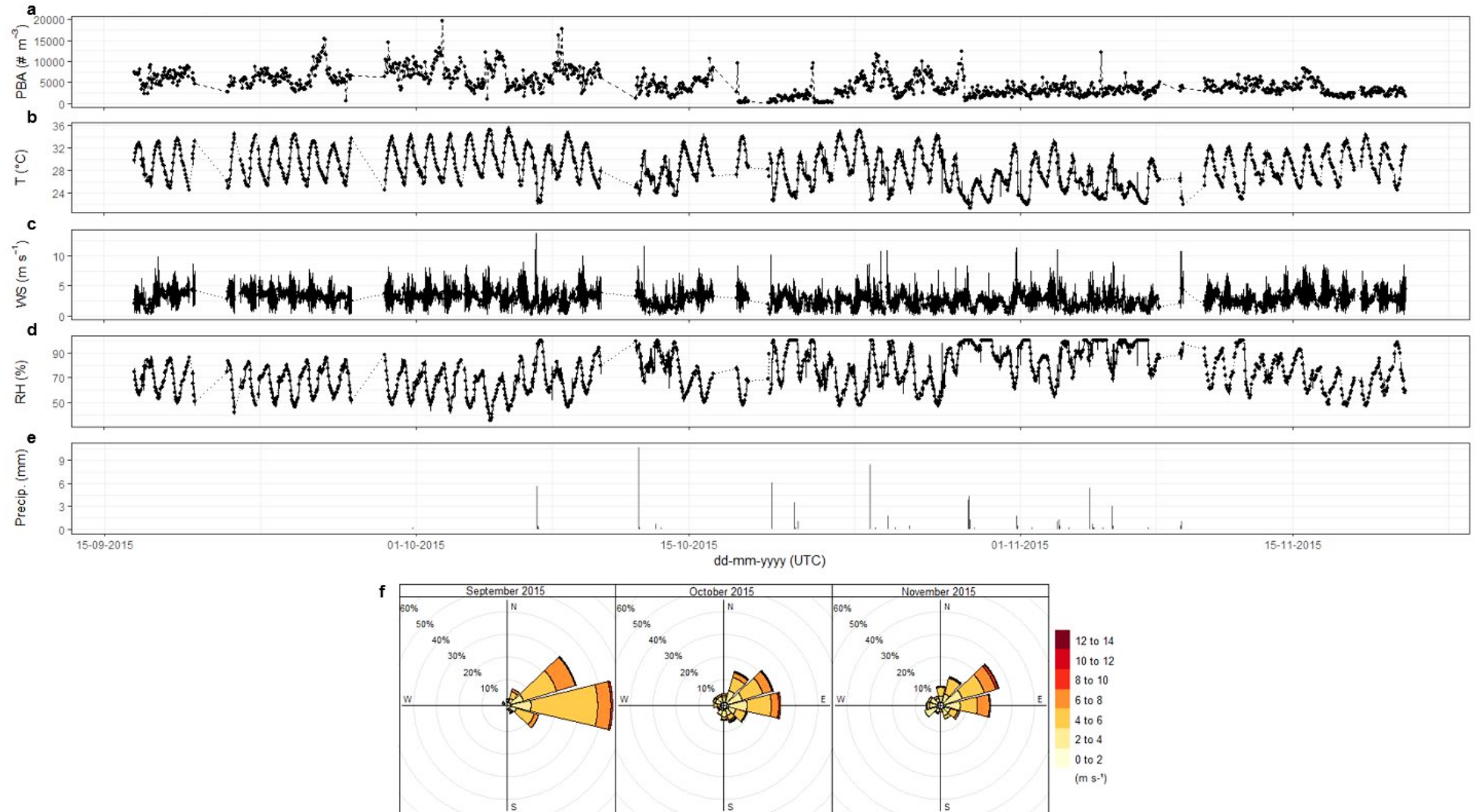
b			
p-values for dry/wet seasons			
	Spores	Pollen	PBA
26 m	< 0.001	< 0.001	< 0.001
40 m	< 0.001	< 0.001	< 0.001
80 m	< 0.001	< 0.001	< 0.001



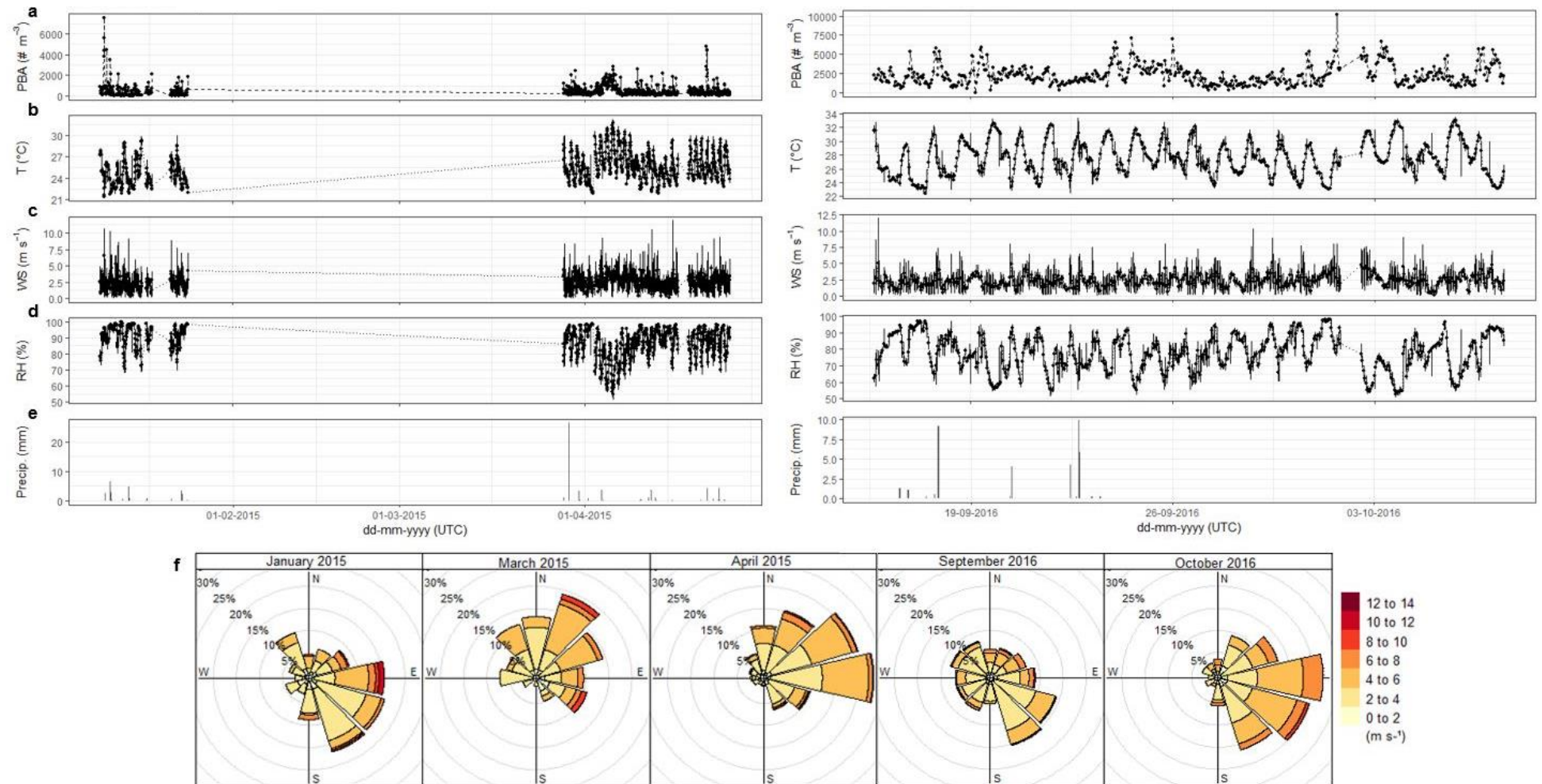
Supplementary Figure 5 – Data from 26 m comprising the 192 h of sampling. Dry season (Aug 2018) presented on the left, and wet season (Mar 2019) on the right panel. (a) PBA concentration ($\# \text{ m}^{-3}$); (b) Air temperature ($^{\circ}\text{C}$); (c) Wind speed (m s^{-1}); (d) Relative Humidity (%); (e) Accumulated Precipitation (mm); (f) Wind rose for the sampled periods with direction and wind speed from 0 to 14 m s^{-1} . Dots (panels a, b, c, d) represent the average for 1-hour period and the vertical lines at each dot represent the range (max and min values) for the hour interval. Only periods with valid PBA results were plotted for all the parameters. Data presented in 1-hour resolution.



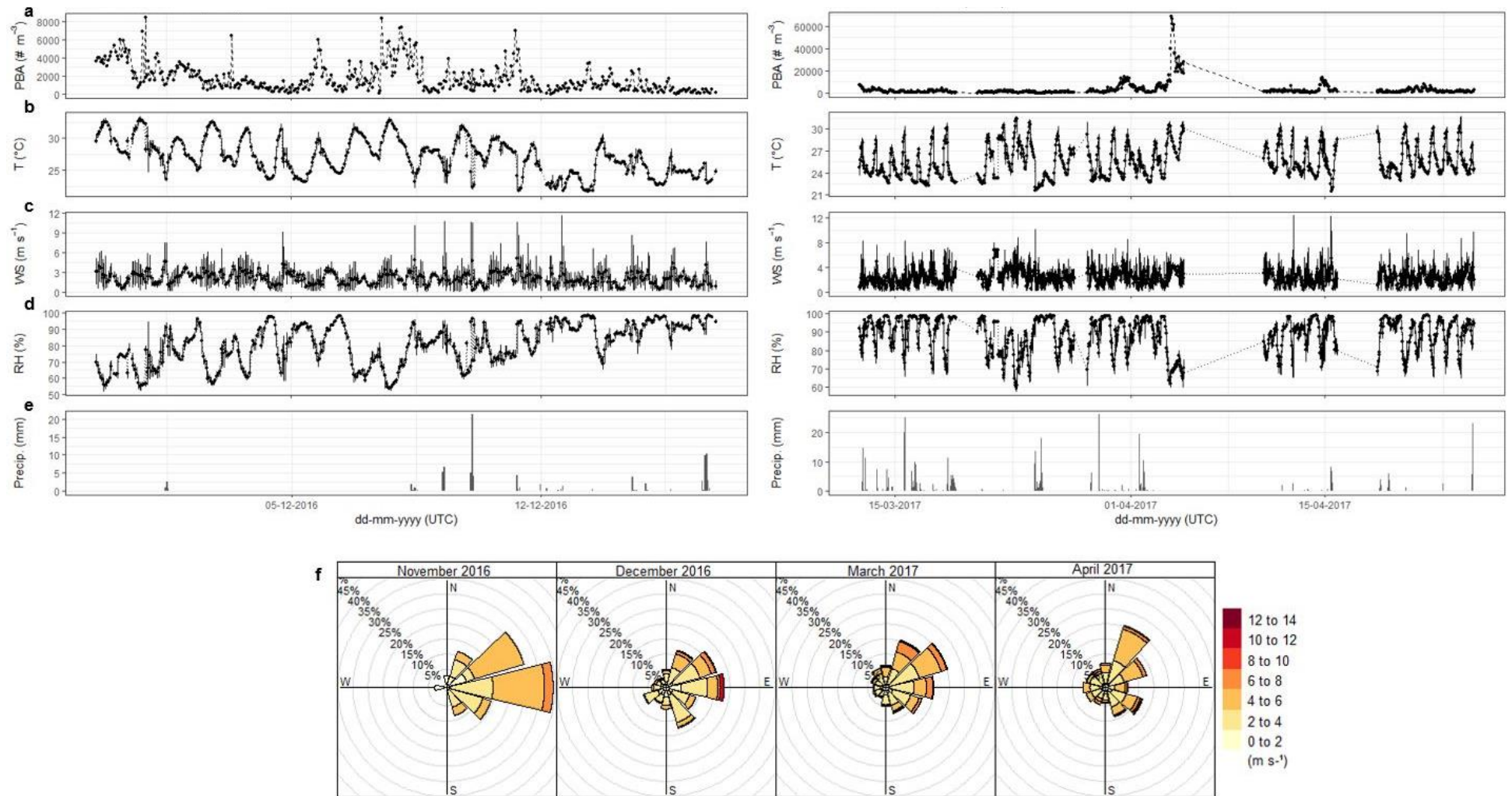
Supplementary Figure 6 – Data from 40 m comprising the 621 h of sampling. Dry season (Sep, Oct 2016) presented on the left, and wet season (Nov, Dec 2016) on the right panel. (a) PBA concentration ($\# \text{ m}^{-3}$), (b) Air temperature ($^{\circ}\text{C}$), (c) Wind speed (m s^{-1}), (d) Relative Humidity (%), (e) Accumulated Precipitation (mm), and (f) Wind rose for the sampled periods with direction and wind speed from 0 to 14 m s^{-1} . Dots (panels a, b, c, d) represent the average for 1-hour period and the vertical lines at each dot represent the range (max and min values) for the hour interval. Only periods with valid PBA results were plotted for all the parameters. Data presented in 1-hour resolution.



Supplementary Figure 7 – Data from 60 m comprising the 1316 h of sampling during the dry season (Sep, Oct, Nov 2015). (a) PBA concentration ($\# \text{ m}^{-3}$), (b) Air temperature ($^{\circ}\text{C}$), (c) Wind speed (m s^{-1}), (d) Relative Humidity (%), (e) Accumulated Precipitation (mm), and (f) Wind rose for the sampled periods with direction and wind speed from 0 to 14 m s^{-1} . Dots (panels a, b, c, d) represent the average for 1-hour period and the vertical lines at each dot represent the range (max and min values) for the hour interval. Only periods with valid PBA results were plotted for all the parameters. Data presented in 1-hour resolution.



Supplementary Figure 8 – Data from 80 m comprising the 1394 h of sampling. Wet season (Jan, Mar, Apr 2015) presented on the left, and dry season (Sep, Oct 2016) on the right panel. (a) PBA concentration ($\# \text{ m}^{-3}$), (b) Air temperature ($^{\circ}\text{C}$), (c) Wind speed (m s^{-1}), (d) Relative Humidity (%), (e) Accumulated Precipitation (mm), and (f) Wind rose for the sampled periods with direction and wind speed from 0 to 14 m s^{-1} . Dots (panels a, b, c, d) represent the average for 1-hour period and the vertical lines at each dot represent the range (max and min values) for the hour interval. Only periods with valid PBA results were plotted for all the parameters. Data presented in 1-hour resolution.



Supplementary Figure 9 – Data from 300 m comprising the 1214 h of sampling during the wet season. Data from 2016 (Nov, Dec) on the left, and for 2017 (Mar, Apr) on the right panel. (a) PBA concentration ($\# \text{ m}^{-3}$), (b) Air temperature ($^{\circ}\text{C}$), (c) Wind speed (m s^{-1}), (d) Relative Humidity (%), (e) Accumulated Precipitation (mm), and (f) Wind rose for the sampled periods with direction and wind speed from 0 to 14 m s^{-1} . Dots (panels a, b, c, d) represent the average for 1-hour period and the vertical lines at each dot represent the range (max and min values) for the hour interval. Only periods with valid PBA results were plotted for all the parameters. Data presented in 1-hour resolution.