



Supplement of

High concentrations of ice crystals in upper-tropospheric tropical clouds: is there a link to biomass and fossil fuel combustion?

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Figure S1. A compendium of the flight trajectories of all the MOZAIC/IAGOS aircraft up to October 4, 2021.



Figure S2. Comparison of the fire radiative power derived from MODIS on the a) Aqua (nadir pass at 1:30pm LT) and b) Terra (nadir pass at 10:30amLT) satellites for July through December (2011-2019). The orange markers show the location of Extreme Ice Events (EIE) in cirrus observed in each month. (Logarithmic scale?)



Figure S3. Spatial distribution of the aerosol optical depth (AOD) per month derived from the MODIS sensor in the Aqua satellite (nadir pass at 1:30pm LT). The AOD plotted is a nondimensional value normalized here to fall between 0 (lowest) to 1 (highest). The black markers show the location of Extreme Ice Events (EIE) observed in each month. The few white regions correspond to the widespread presence of clouds that render impossible the determination of AOD.



Figure S4. Spatial distribution of the horizontal wind divergence at 200 hPa per month, determined from ERA5 reanalysis (2011-2019). The blue markers show the location of Extreme Ice Events (EIE) observed in each month.



Figure S5. Spatial distribution of the outgoing longwave radiation (OLR) per month determined from ERA5 reanalysis (2011-2019). The black markers show the location of Extreme Ice Events (EIE) observed in each month.



Average dust mass concentrations for January through December. These are average concentrations between 8 and 12 km adjusted to standard temperature and pressure. The EIE are shown as black markers.



Figure S7. The same as Fig. S6 but for OC+BC mass concentrations.



Figure S8. The same as Fig. S6 but for sulfate mass concentrations.

	CO Source			Season	
Region	Biomass	Fossil Fuel	Both	Dry	Rainy
	Burning	Combustion			
Australia &	38	11	45	7	15
Oceania	[69]	[13]	[73]	[11.5]	[31.0]
Persia, India &	61	46	98	12.5	22.6
Southeast Asia	[104]	[39]	[117]	[14.2]	[27.0]
Northern Hemisphere	15	20	34	13.6	13.7
Africa & Atlantic	[16]	[17]	[28]	[10.6]	[11.0]
Northern Hemisphere	7	5	12	7.5	13.6
Africa & Atlantic	[9]	[3]	[11]	[3.0]	[10.2]

 Table S1

 Average [Standard Deviation] Carbon Monoxide Anomalies

Table S2
Average [Standard Deviation] Carbon Monoxide Anomalies

Associated with Ice ciouus						
	CO Source					
Region	Biomass	omass Fossil Fuel				
	Burning	Combustion				
Australia &	63	16	75			
Oceania	[90]	[15]	[98]			
Persia, India &	91	58	145			
Southeast Asia	[128]	[42]	[144]			
Northern Hemisphere	26	27	52			
Africa & Atlantic	[22]	[19]	[33]			
Northern Hemisphere	5	6	10			
Africa & Atlantic	[6]	[2]	[7]			

Associated with Ice clouds

Name	Latitude	Longitude
Bangalore	11.4	12.9716
Bangkok	10.2	13.7563
Beijing	19.6	39.9042
Cairo	20.1	30.0444
Chennai	10.5	13.0827
Chongqing	14.8	29.4316
Delhi	28.5	28.7041
Dhaka	19.6	23.8103
Guangzhou	12.6	23.1291
Jakarta	10.5	-6.2088
Karachi	15.4	24.8607
Kinshasa	-13.2	4.4419
Kolkata	14.7	22.5726
Lagos	13.5	6.5244
Lahore	11.7	31.5204
Manila	13.5	14.5995
Mumbai	20	19.076
Osaka	19.3	34.6937
Rio de Janeiro	13.3	-22.9068
Sao Paulo	21.7	-23.5505
Shanghai	25.6	31.2304
Shenzhen	11.9	22.5431
Tianjin	13.2	39.3434
Tokyo	37.5	35.6762

Table S3: Names and locations of the Megacities shown in Figures 1 and 6