Diurnal, synoptic and seasonal variability of atmospheric CO_2 in the Paris megacity area

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Supplementary material

S1 Back trajectories

Back trajectories from the HYSPLIT model were calculated for the Paris city using wind fields from the NOAA-NCEP/NCAR reanalysis data archives at a 2.5° x 2.5° and 6 h resolution (http://rda.ucar.edu/datasets/ds090.0/). They were run for 72 h backwards and started at 10 m AGL. They were then plotted and colored by clusters of several days using the OPENAIR (http://www.openair-project.org/) backtrajectory plotting functions. These clusters are shown on Fig. S1 for each month of the period of study.

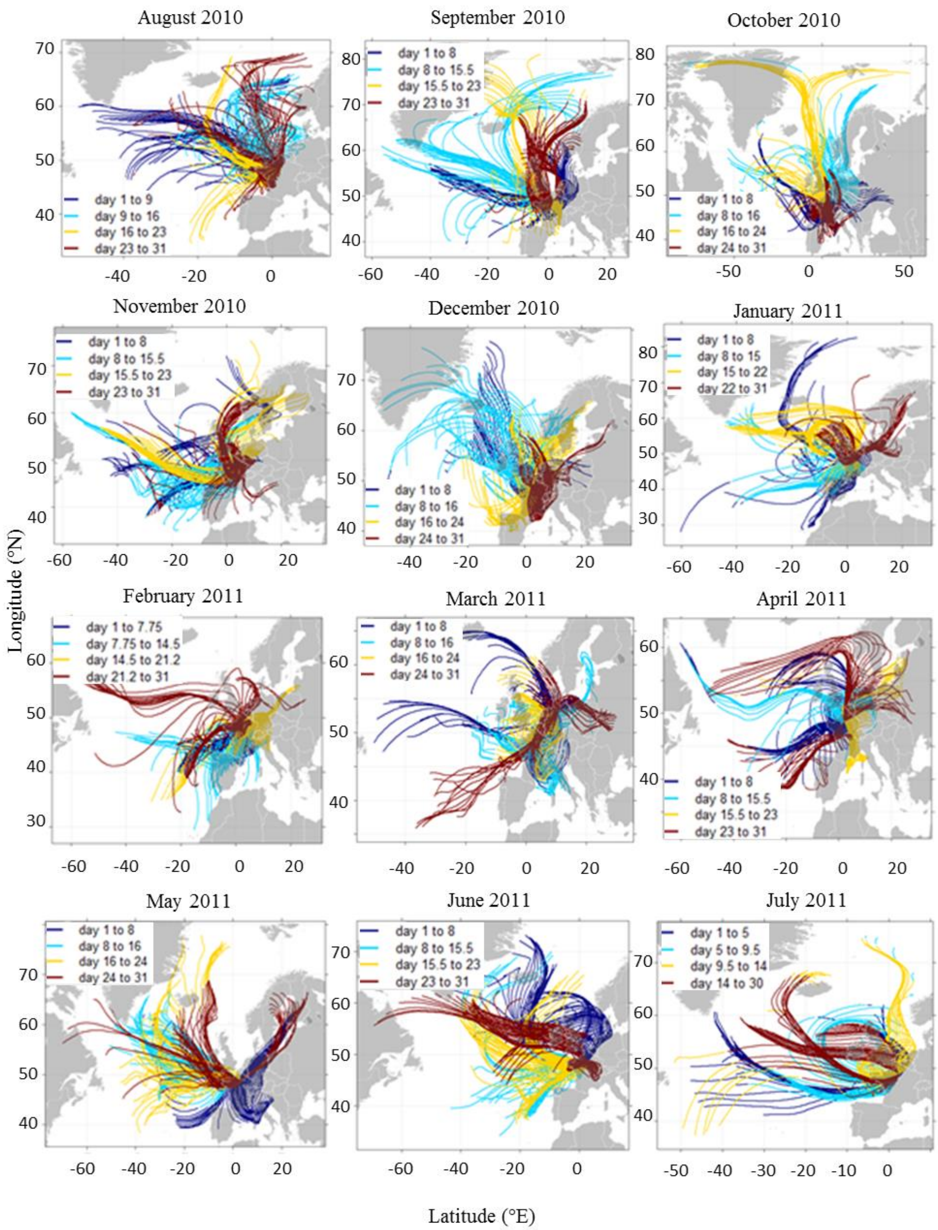

Figure S1. Clusters of back trajectories calculated for Paris withthe HYSPLIT model for each month of the period of study (8 August 2010–13 July 2011). See text above for technical details.

S2 Time series

Figure S2 shows the time series of the hourly CO_2 mean concentration recorded at the five stations of the Paris network and at the remote coastal site of MHD. The data have been colored according to the wind classes defined in section 3.1 (*local*, *northeast*, *southeast*, *southwest*, *northwest* and *remote classes*). What first appears on the time series is (as expected) that the wind direction and speed are part of the main factors controlling the CO_2 concentration values recorded at the different stations. The urban and peri-urban stations are characterized by higher concentrations and a much larger variability than the rural and coastal sites. The highest variability is observed on the GON time series, followed by EIF and GIF. We can note as well that the highest concentrations recorded at the southern rural sites (TRN50 and TRN180) and remote station of MHD occur usually during local events or northeast winds loaded with anthropogenic emissions from large emitting spots such as Benelux and Ruhr areas as observed in former studies (e.g. Messager et al, 2008 ; Xueref-Remy et al., 2011). We can also observe simultaneous variations between the sites for the *local class* (wind speed lower than 3 m s^{-1}): for example peaks of CO_2 concentration can be observed in all the stations of IdF on mid of February or end of March 2011, which corresponds to two pollution events noticed by AIRPARIF (www.airparif.asso.fr). However, there are some other dates (not reported by AIRPARIF as pollution events) during which the CO_2 concentration reaches high values at the urban and peri-urban stations and also sometimes in the rural stations (ex: 20-25 August and 22-25 October). Finally, the *remote class* signals (wind speed higher than 9 m s^{-1}) are those with the lowest CO_2 concentrations variability due to atmospheric ventilation and dilution.

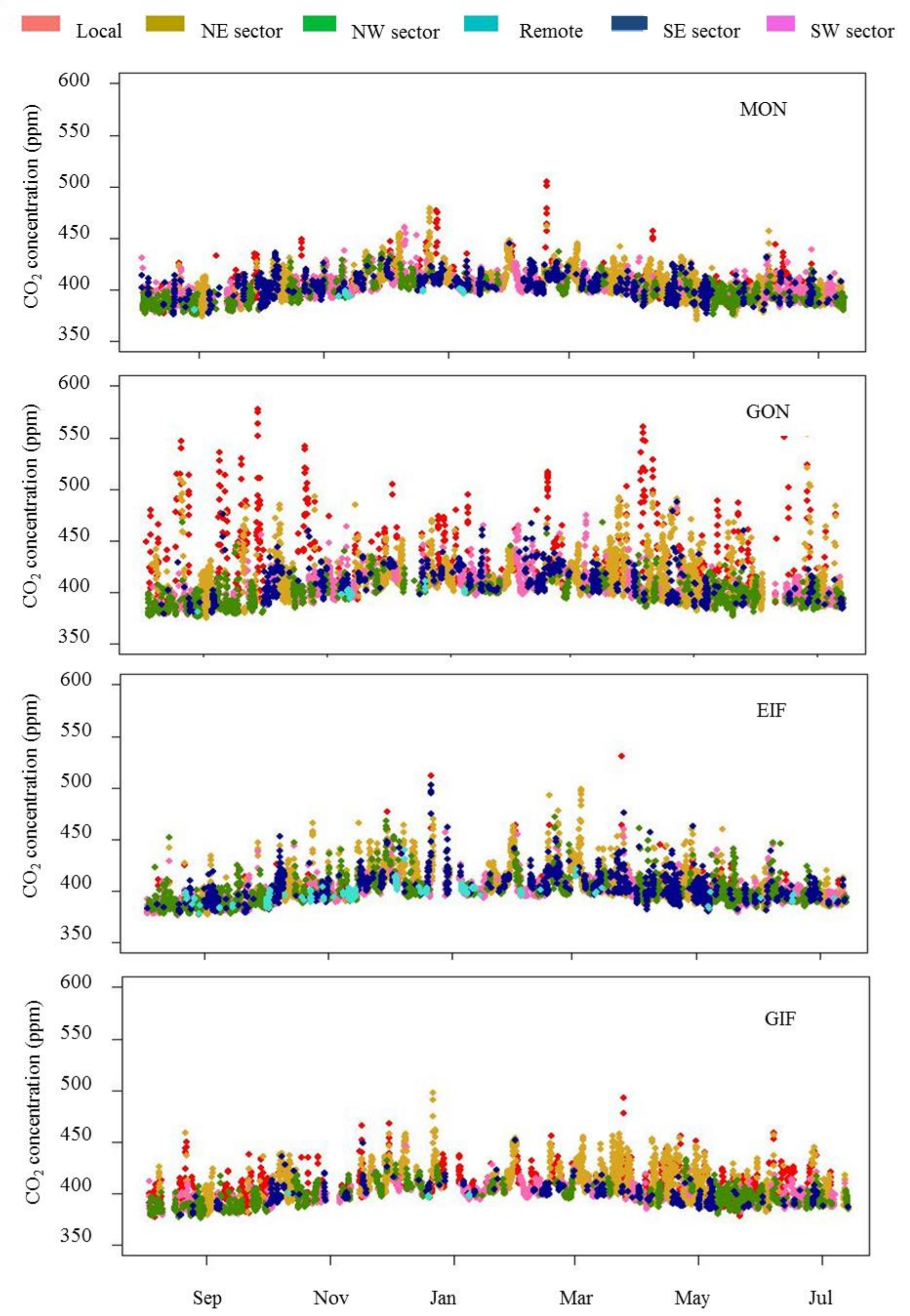

Figure S2 (beginning). Time series of CO_2 concentration (1 hour averages) recorded during the CO_2-Megaparis period and colored by wind classed for sites MON, GON, EIF and GIF.

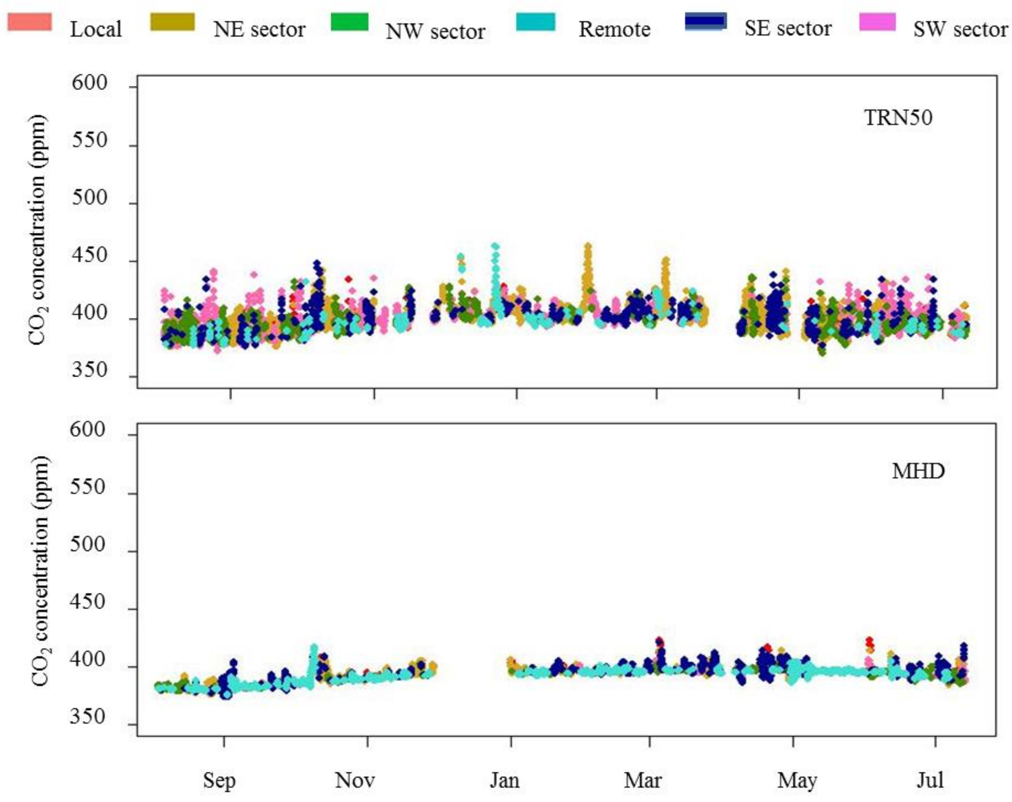

Figure S2 (continued). Time series of CO_2 concentration (1 hour averages) recorded during the CO_2-Megaparis period and colored by wind classed for sites TRN50 and MHD.

S3 CO_2 diurnal cycles data

Table S3. Amplitude, variation of the amplitude, minimum and maximum of the CO_2 diurnal cycle over the year and by season at the different sites. All values are given in ppm of CO_2. The variation of the amplitude is calculated as the mean of the standard deviation on the minimum and maximum concentrations of the corresponding cycle.

	MON	GON	EIF	GIF	TRN50	TRN180	MHD
				Annual			
Amplitude	14.9	30.6	11.2	18.2	15.5	6.5	2.6
Variation	12.8	23.4	16.3	12.9	11.1	10.0	6.6
Min	396.6	398.2	398.6	396.3	393.5	393.4	392.0
Max	411.4	428.7	409.8	414.5	409.0	400.0	394.6
				Spring			
Amplitude	20.1	43.1	18.9	27.5	20.7	10.3	3.8
Variation	10.1	20.2	15.9	12.2	10.1	8.9	4.0
Min	393.3	395.7	398.5	395.0	392.8	393.0	395.9
Max	413.5	438.8	417.4	422.5	413.5	403.2	399.7
				Summer			
Amplitude	21.5	38.0	9.5	24.7	22.8	8.2	3.7
Variation	8.7	21.1	7.1	9.7	9.7	6.0	7.5

Min	385.7	386.0	388.2	386.6	385.2	385.9	387.0
Max	407.3	424.0	397.7	411.2	408.0	394.1	390.6
			Autumn				
Amplitude	15.3	32.6	13.4	19.2	18.5	8.3	2.8
Variation	10.9	22.5	15.2	11.2	11.2	9.0	6.4
Min	394.8	395.9	396.3	392.9	389.0	388.7	388.2
Max	410.1	428.6	409.7	412.1	407.5	397.0	391.0
			Winter				
Amplitude	5.7	13.9	8.3	5.9	5.1	2.7	1.4
Variation	12.4	17.0	16.3	12.2	9.4	9.1	3.0
Min	409.5	412.7	407.4	408.5	403.7	402.9	395.7
Max	415.1	426.7	415.7	414.4	408.8	405.6	397.1

S4 Boundary layer observations from August 2010 to March 2011 in Jussieu

Boundary layer height was monitored from August 2010 to March 2011 on the QUALAIR platform in Jussieu. In the cold months, this parameter is often below the Eiffel tower station (EIF) in the early to mid-morning as shown in Fig. S4.

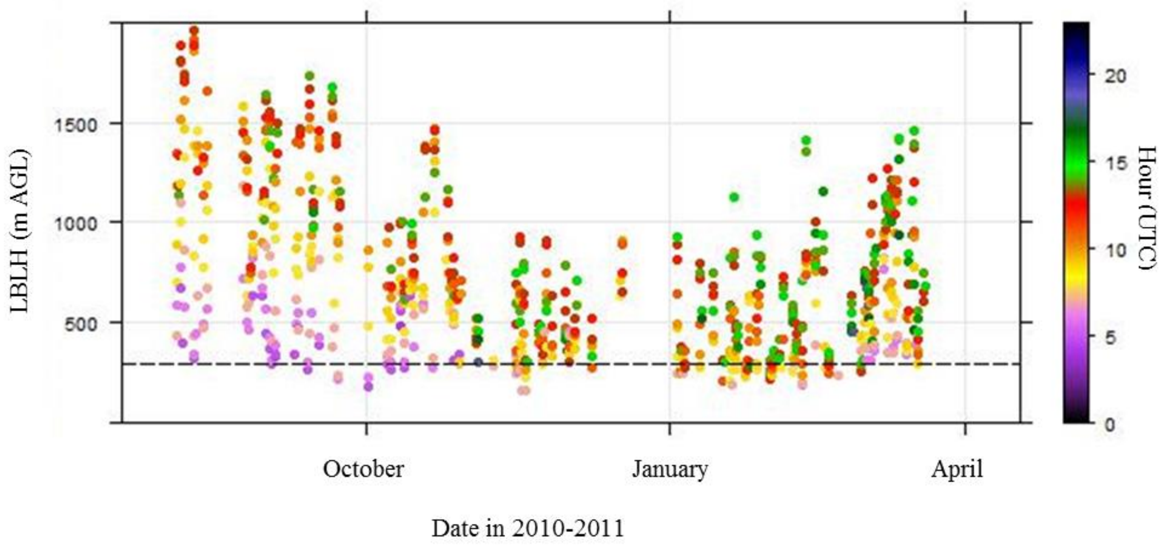

Figure S4. Hourly means of the lowest estimate of the boundary layer height LBHL (base of the entrainment zone, in m AGL) observed at the QUALAIR station in the center of Paris from 4 August 2010 to 31 March 2011. The color scale indicates the hour of the day, in UTC. Measurements were done only during daytime, between 5 h and 18 h UTC. The dashed line indicates the height of the EIF station (317 m AGL).

S5 CO_2 wind roses

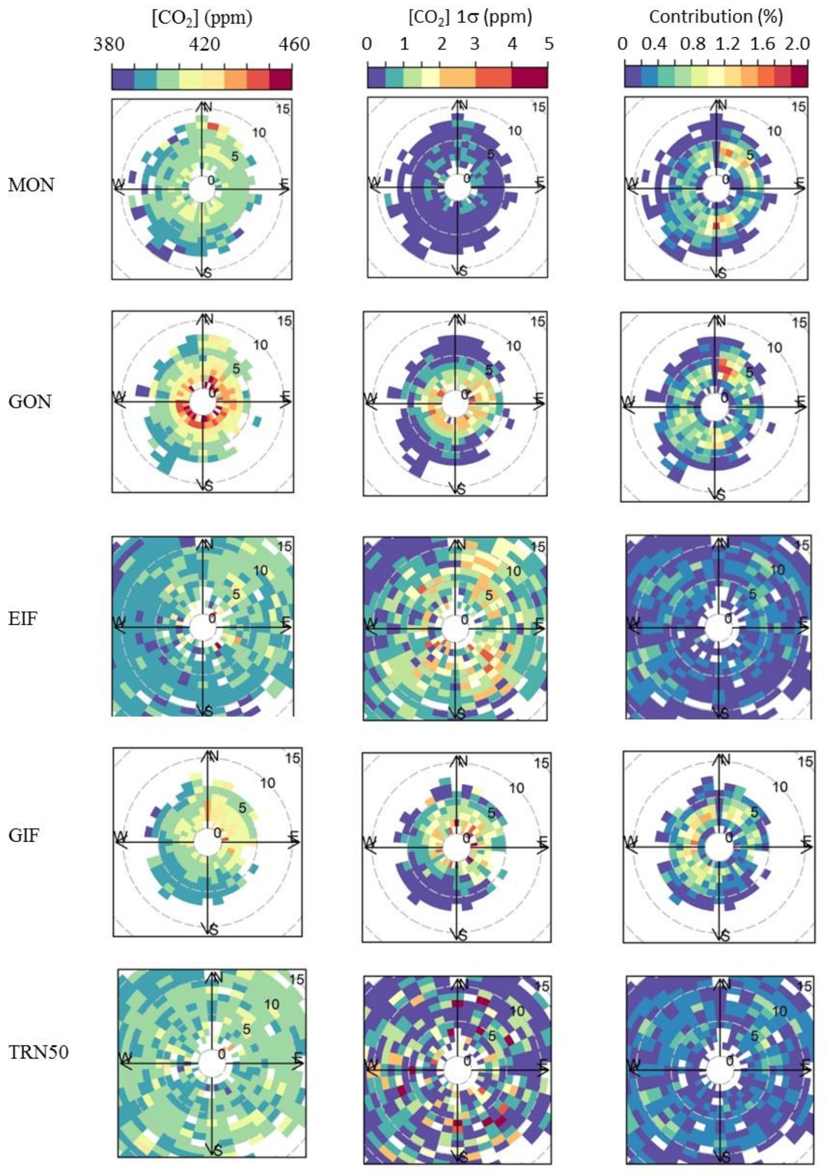

Figure S5.1. CO_2 wind roses during nighttime (22-2h UTC) at the five Paris regional stations on the period of study (8 August 2010-13 July 2011). Here, wind speed is shown only up to 15 m s^{-1} on this figure, as on Fig.12. The data have been seasonally adjusted.

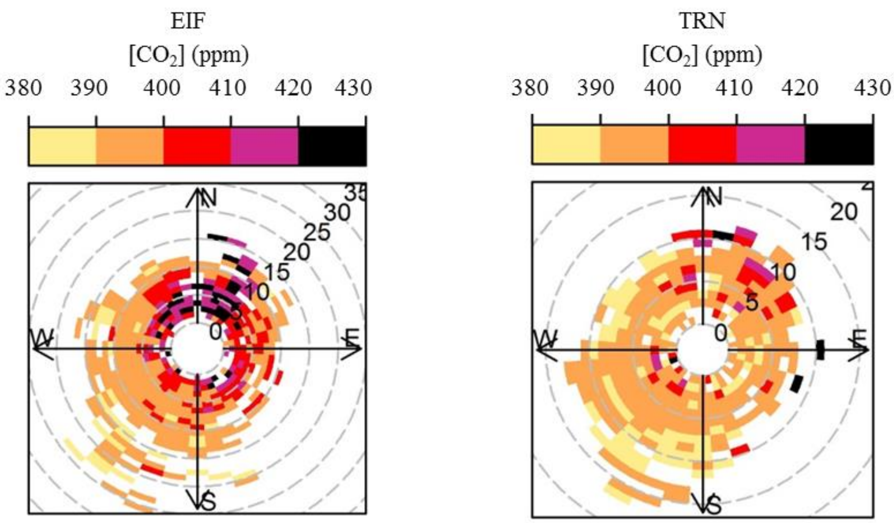

Figure S5.2. CO_2 wind roses at EIF and TRN50 during daytime on the full range of wind speed encountered at these stations on the period of study (8 August 2010-13 July 2011). The data have been seasonally adjusted.

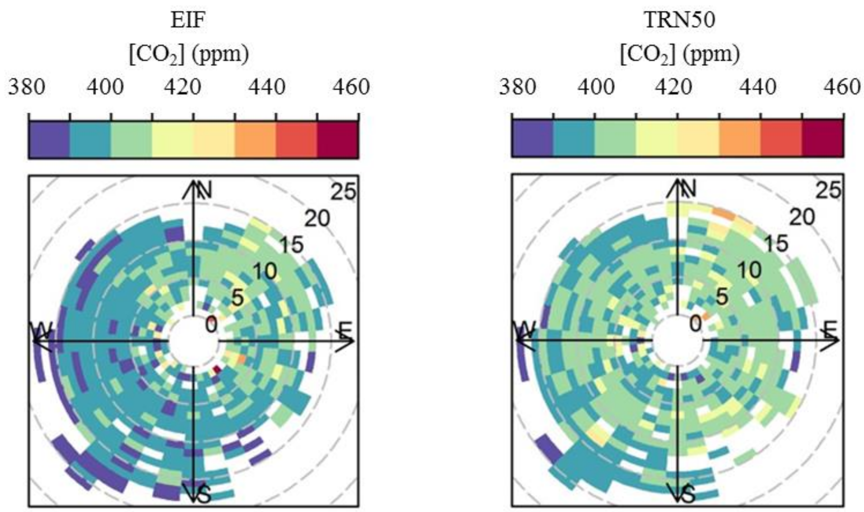

Figure S5.3. CO_2 wind roses at EIF and TRN50 during nighttime on the full range of wind speed encountered at these stations on the period of study (8 August 2010-13 July 2011). The data have been seasonally adjusted.