Auxillary Material for: The Fossil Fuel Emission Source of Tokyo estimated directly from measurements of the TCCON site Tsukuba

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1 Wind direction vs. time of day

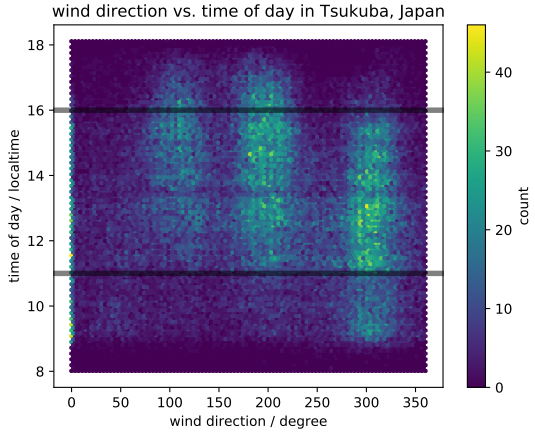

Figure 1. Histogram of Wind directions vs. time of day. This graph shows that between 11:00 and 16:00 there is only weak correlation between time of day and wind direction. The horizontal lines mark the lower and upper limit of the densely measured time of day. The measurements between 170 and 240 degree wind direction correspond to wind from Tokyo area. This graph is generated from the Data of the TCCON station in Tsukuba using the script `plot_daytime_vs_direction.py`.

2 Using harmonics to fit trend, daily cycle, and yearly cycle

Figure 2 and 3 shows the result of repeating the calculations from the paper using fitting procedure based on sines and cosines (i.e. Thoning et al., 1989), implemented using the ccgfilt library (available from NOAA via ftp://ftp.cmdl.noaa.gov/user/thoning/ccgcrv/) gives an idea of the impact of the fitting on the results.

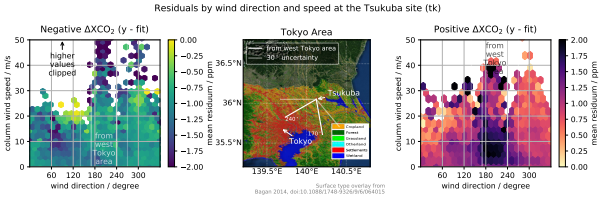

Figure 2. Reproduction of the hexbin visualization of residuals multiplied by wind speed as in Figure 3 of the paper, but when using harmonics (sines and cosines) instead of polynomials as fitting procedure for trend, yearly cycle, and daily cycle.

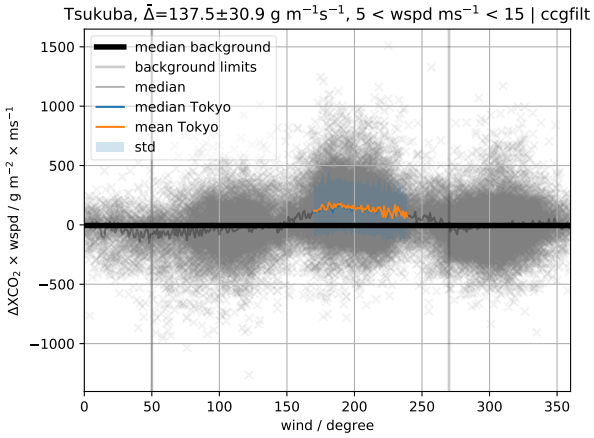

Figure 3. Reproduction of the residuals multiplied by wind speed as in Figure 5 of the paper, but when using harmonics (sines and cosines) instead of polynomials as fitting procedure for trend, yearly cycle, and daily cycle.

Figure 4 shows the daily cycle when using harmonics before correcting it. Figure 5 shows the daily cycle after correction to remove the daily cycle in the background. The daily from Tokyo area after correction shows a pattern similar to the pattern reported by Nassar et al. (2013).

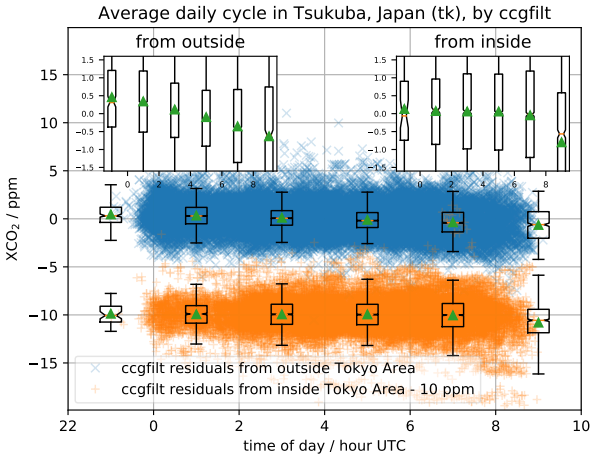

Figure 4. Daily cycle calculation before correction when using harmonics instead of polynomials.

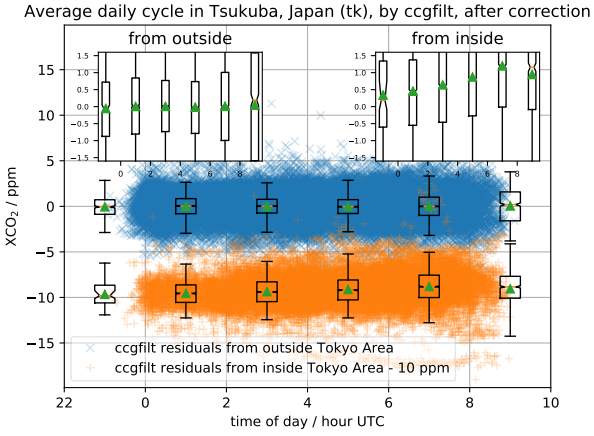

Figure 5. Daily cycle calculation after correction when using harmonics instead of polynomials.

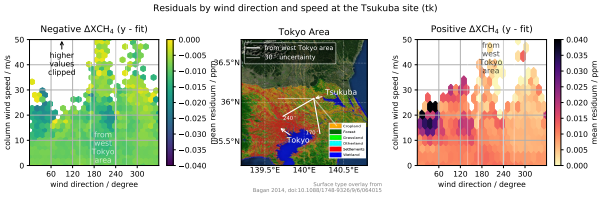

Figure 6. Reproduction of the residuals multiplied by wind speed as in Figure 3 of the paper, for methane instead of carbon dioxide.

3 Residuals for methane

The method from the publication accompanied by this supplement can also be used for other gas species. Figure 6 shows the residuals for methane.

4 Radiosonde data from Pangea

The four years of radiosonde data from Tateno is also available in monthly format from the PANGEA data archive (Ohkawara, 2011a, b, c, d, e, f, g; Ijima, 2011a, b, c, d, e, 2012a, b, c, d, e, f, g, h, i, j, k, l, m, n, o, p, 2013a, b, c, d, e, f, g, h, 2014a, b, c, d, e, f, g, h, i, j, k, l, m, n, o, p, 2015a, b, c, d, e, f, g, h, i, j, k, 2016a, b, c, d, e, f, g, h, i, j, k, l).

5 Trajectory calculations for Tokyo

The HYSPLIT model (Stein et al., 2015) allows calculating high resolution trajectories. This was used to verify the assumptions of vertical transport in this publication. Most of the trajectories calculated for this publication only extend up to 1000m even though they extend much further in horizontal direction than the 65 km from Tokyo to Tsukuba. This shows that it is viable to use the wind speed in the lower 1000m as base for a mean wind speed profile. The trajectory graphs show sample results.

These were run from http://ready.arl.noaa.gov/HYSPLIT.php.

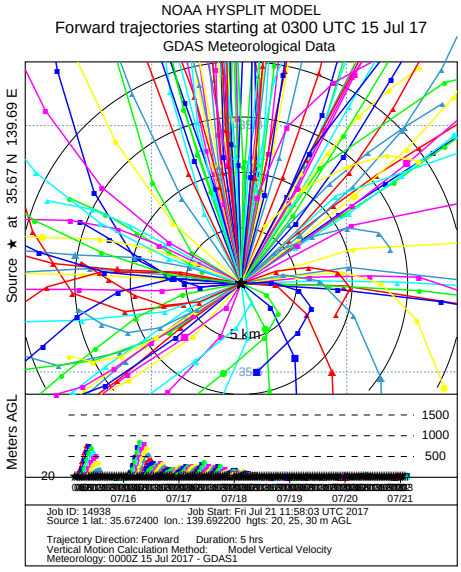

Figure 7. 5 hours trajectory plot starting at Tokyo. Required information to reproduce the graph is contained in the figure. Published with permission from NOAA ARL, under the condition that it is made it clear that they are not producing these images for us. Which we hereby do: To produce these images we used the great HYSPLIT from NOAA ARL, but the images were not created by someone for us.

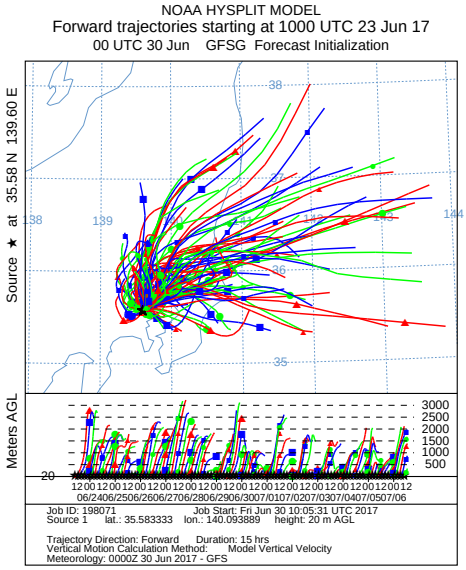

Figure 8. Required information to reproduce the graph is contained in the figure. Published with permission from NOAA ARL, under the condition that it is made it clear that they are not producing these images for us. Which we hereby do: To produce these images we used the great HYSPLIT from NOAA ARL, but the images were not created by someone for us.

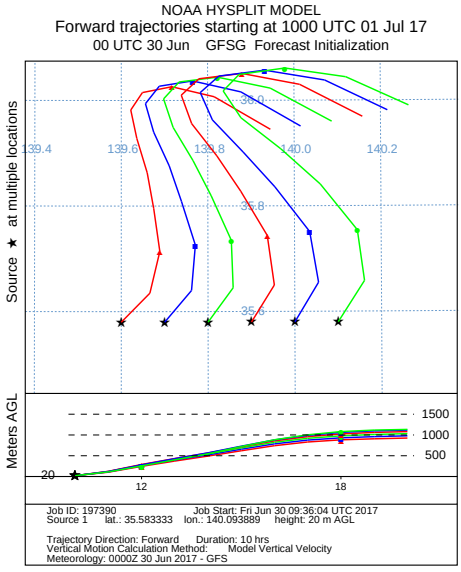

Figure 9. 10 hours trajectory plot starting at Tokyo. Required information to reproduce the graph is contained in the figure. Published with permission from NOAA ARL, under the condition that it is made it clear that they are not producing these images for us. Which we hereby do: To produce these images we used the great HYSPLIT from NOAA ARL, but the images were not created by someone for us.

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