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Atmospheric Measurement Techniques Discussions

Interactive comment on "Comparison of OMI NO_2 observations and their seasonal and weekly cycles with ground-based measurements in Helsinki" *by* I. Ialongo et al.

Anonymous Referee #2

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"Comparison of OMI NO2 observations and their seasonal and weekly cycles with ground-based measurements in Helsinki" by Ialongo et al. (2016) presents a comparison of OMI NO2 with ground-based measurements over Helsinki. This is a nicely conceived study and, as the authors point out, it is one of a handful that focuses on higher latitudes. If the authors consider the issue I elaborate on below and take steps to address it in a meaningful way then I recommend publication.

Main issue:

This study finds agreement to within about 5% between OMI-SP and Pandora total NO2 VCDs. While remarkable, I believe this is not real and is likely the result of cancelling errors. It is now well established that OMI SCDs are high biased by something like 15-

30% (higher % corresponds to smaller SCD) (see Belmonte-Rivas, 2014; Marchenko et al., 2015; van Geffen et al., 2015), and that this bias largely gets incorporated into stratospheric VCDs. Indeed, this has prompted a large effort to redo the spectral fitting by both NASA and KNMI (Marchenko et al., 2015; van Geffen et al., 2015). By comparing SP (and DOMINO) with ground-based using total columns, the OMI total VCD is high biased by something like 25%.

This is likely being cancelled by a spatial resolution effect. Your Pandora is located in the middle of a relative small (on the order of 30 km) NO2 hotspot, at least in an average sense. Even on a fine grid, the effect of the coarse OMI pixel resolution will be to always include small, upwind columns. Thus one would expect the Pandora, with an effective spatial resolution on the order of a couple km, to be systematically higher. Likely exacerbating this, it appears you use even the largest track positions which have cross-track resolutions of $\sim$150 km. You can see a hint of this in your Figure 3c, but the effect will be present since even the smallest pixels are 24 km across. This effect is why the slope of an OMI vs. ground-based scatterplot is typically 0.4-0.7 (see, McLinden et al., 2014 or Kharol et al., 2015, but there are many other examples). There is no reason to expect a slope of unity here given the relative location of NOx sources, Pandora, and OMI pixel sizes. I tried to demonstrate this in Figure 1, below, using your average map and proxies for OMI pixels which clearly are sampling outside the peak NO2 area.

Knowing that there is a large systematic error in the stratospheric VCDs, it is not reasonable to keep this comparison as-is. Here are some possible ways to remedy this:

1. Wait until the next version of the SP product is available which corrects the spectral fitting issue. My understanding its release is imminent, and since you have SP co-authors, they might give you early access.

2. Compare tropospheric VCDs. This means you will have to estimate the stratospheric portion of the Pandora VCD and remove it. You could use another satellite, SCIAMACHY, OSIRIS, or other, or use a model.

3. Scale the OMI stratospheric VCD by ∼0.75 or 0.8 and recalculate total VCD. You might be able to find a better scaling (but 0.75-0.8 should be about right) using papers such as Marchenko et al., 2015 and Adams et al., 2016.

4. One of your co-authors is Nick Krotkov. He might have another suggestion.

The spatial resolution issue is harder to address, although it needs to be mentioned and cited as a source of comparison bias. One could estimate the effect by getting a map of gridded emissions, say from HTAP, and smoothing it to OMI resolution (∼50 x 30), and then comparing the smoothed and unsmoothed VCDs at the location of the Pandora.

Other points:

1. Show a scatterplot of OMI vs. Pandora.

2. What precisely did you do to filter the OMI data? E.g., were snow covered pixels removed? You hint at this in the analysis, but please state.

3. Add lat/lon and a scale to figure 1. The OMI pixel outlines would also be instructive (i.e., a nicer version of what I did above).

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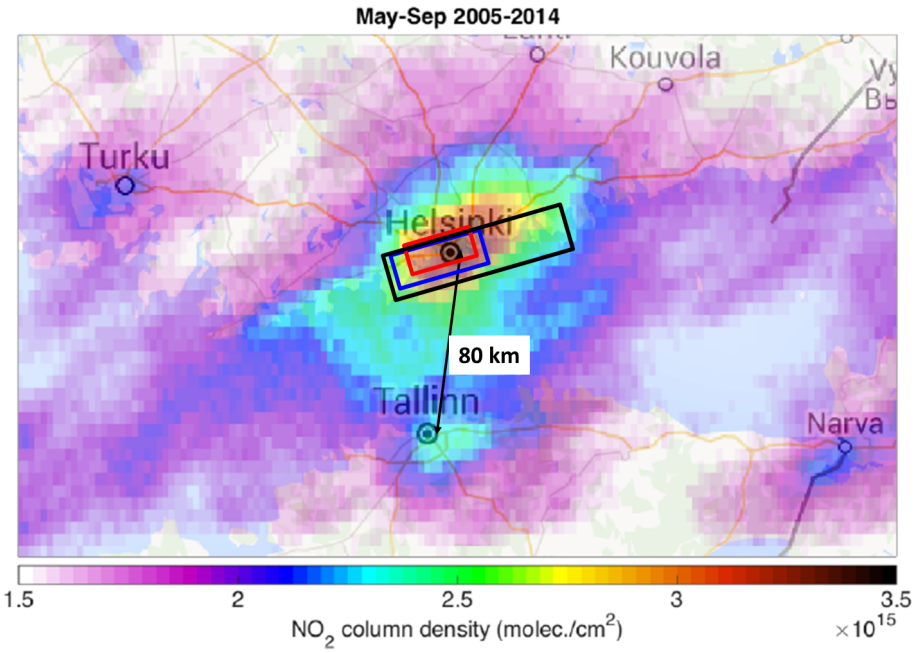

Fig. 1. Figure 1 from Ialongo et al., overlaid with three representative OMI pixels: red/small (13 km x 27 = 350 km2), medium/blue (15 km x 38 km = 570 km2), and large/black (20 km x 78 km = 1560 km2).