Response to Reviewer #1:

First of all, thank you for your valuable comments and suggestions. The added or modified parts are pained in a red color in the revised manuscript.

The paper by Han et al. greatly improved after their latest revision. Their findings underline the necessity of using averaging kernels when comparing remote sensing data with model results. Furthermore, their sensitivity studies add to a better understanding of the uncertainties in the modelling of NO_2, which is useful information e.g. when using satellite data for emission estimation. Although to my personal taste it is not very concisely written (repeticion could be avoided and more compact sentences could be used throughout the paper) I consider it fit for publication after some technical corrections:
Reply: We try to do our best for removing repetitive parts throughout the manuscript.

Section 1 (line 119): leave out quotation marks around apples and oranges.
Reply: We removed the quotation marks (p. 5, line 118).

Section 1 (line 113): leave out "(ii) uncertainty in the magnitude of emission fluxes of NO_x", as a factor for the earlier mentioned "evaluation of the bottom-up NO_x emissions".
Reply: It may be “line 131”. We removed this part in the revised manuscript (p. 5, line 129).

Section 2.2 (line 262): Consider moving "Fig. 4 illustrates the main processes of the comparison study" to the start of the paragraph in line 255.
Reply: It is a better idea. We moved the sentence to the beginning (p. 10, line 251).

Section 2.2 (line 254): "interpolated into the OMI grid cells" --> "interpolated to the OMI footprints"
Reply: Thank you for your comment. We corrected it (p. 10, 252)

Figure 4: Change "Gridding horizontal CMAQ domain to OMI grid" to "Interpolate CMAQ simulations to OMI footprints"
Reply: We also corrected it in Fig. 4 (please, refer to Fig. 4).

Section 2.2 (line 254-258) : "The AKs are sometimes (...) OMI footprint cells." Rewrite this part more concisely. The main reason behind interpolating model simulations to satellite footprints is that the AKs are defined for the footprints, not for the model grid.
Reply: We changed this part (see, p. 10, lines 254-255).

Response to Reviewer #2:

KNMI/DOMINO 2 tropospheric (vertical) column NO_2 products can be directly compared to CMAQ simulated vertical columns of tropospheric NO_2. AK is calculated, on the other hand, in order to compare model simulated SLANT columns directly to the observed slant columns (P. 1289, Eskes and Boersma, 2003). If one really wants to compare to satellite vertical columns, only the geometric AMF should be used in the satellite retrieval (i.e., AMF does not include the correction of a priori NO_2 vertical profiles in the troposphere). In this paper, the standard DOMINO2 vertical columns of tropospheric NO_2 are compared with CMAQ columns weighted by AK. I think it is incorrect. I therefore stand by my original criticisms of the manuscript.

Reply: We do not have any doubt about the methodology we used in this study, i.e. direct comparison between the satellite-observed and model-estimated tropospheric NO_2 columns with the consideration of AKs. There have been many publications in which the AKs have been applied. If reviewer's comment is right, these publications were all conducted, based on wrong idea (e.g. Herron-Thorpe et al., 2010; Huijnen et al., 2010; Ghude et al., 2013; Pfister et al., 2013; Zyrichidou et al., 2013; Huang et al., 2014; Itahashi et al., 2014). It is hard to believe that these qualified publications are all wrong. Also, refer to User's Guide of DOMINO data product v2.0 (p. 17, Boersma et al., 2011). Following is the comment from Drs. Eskes and Boersma via an email: "Direct comparison of vertical columns from a CTM with the retrieved columns. This is a poor (wo)man's approach, because this comparison is influenced by inaccuracy in the *a-prior* information from our TM4 model". Again, we do not have any doubt about our approach. Below are theoretical derivations using the notations from Eskes and Boersma (2003) for your reference. If you take a look at Eq. (4) below, alternatively retrieved slant can be compared with modeled slant (mx). Again, this is an alternative way to Eq. (5) (i.e., $S=mx$).

Averaging kernels (AKs) define the relation between the retrieved quantities and the true atmospheric state (Eq. 1).

$$\begin{aligned} AK &= G_y K_x \\ &= \frac{\partial R}{\partial y}\frac{\partial F}{\partial x} \\ &= \frac{\partial \hat{x}}{\partial x} \end{aligned} \qquad \text{..... Eq. (1)}$$

$$\begin{aligned} V &= \hat{x} \\ &= \frac{S}{M(x_a, b)} \end{aligned} \qquad \text{..... Eq. (2)}$$

The vertical retrieved column (Eq. 2) is put into the Eq. (1), then, we can obtain AK defined as the ratio of scattering weight (m) to air mass factor (M). Therefore, the AKs have a connection to the scattering weight (m) and air mass factor (M) as expressed in the definition of AKs (Eq. 3).

$$AK = M(x_a, b)^{-1} \frac{\partial S}{\partial x} = M(x_a, b)^{-1} \cdot m \qquad \text{..... Eq. (3)}$$

where G_Y: sensitivities of retrieval (R) to measurement(y)
K_x: sensitivities of forward model (F) to the state (x)
$\hat{x}$: retrieved quanties
x: true distribution of trace gas
V: retrieved vertical column ($\hat{x}$)
S: slant column
M: air mass factor
x_a: a prior assumed trace profile
b: a prior assumed model parameter
m: altitude − dependent scattering weight

As reviewer pointed out, the satellite SLANT column is directly compared with a modeled slant column using the AKs (or scattering weight) (p. 1289, Eskes and Boersma, 2003). It is described by Eq. (4).

$$\begin{aligned} S &= M \cdot V \\ &= M \cdot AK \cdot x \\ &= M \cdot \frac{\partial \hat{x}}{\partial x} \cdot x \\ &= \frac{\partial S}{\partial \hat{x}} \cdot \frac{\partial \hat{x}}{\partial x} \cdot x \\ &= \frac{\partial S}{\partial x} \cdot x \\ &= m \cdot x \end{aligned} \qquad \text{..... Eq. (4)}$$

On the other hand, satellite-retrieved vertical columns can also be directly compared to model-simulated vertical columns of tropospheric NO_2 using AKs. Thus, the comparison through the AKs is no longer complicated by large systematic errors caused by the unrealistic *a priori* assumption on the NO_2 profiles. It is also described by Eq. (5).

$$\begin{aligned} V &= \frac{S}{M} \\ &= \frac{S}{\frac{\partial S}{\partial \hat{x}}} = S \cdot \frac{\partial \hat{x}}{\partial S} \\ &= \frac{\partial S}{\partial x} \cdot x \cdot \frac{\partial \hat{x}}{\partial S} \\ &= x \cdot \frac{\partial \hat{x}}{\partial x} \\ &= x \cdot AK \end{aligned} \qquad \text{..... Eq. (5)}$$

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