Measurement report: Regional characteristics of seasonal and longterm variations in greenhouse gases at Nainital, India and Comilla, Bangladesh, by S. Nomura, M. Naja, M. K. Ahmed, H. Mukai, Y. Terao, T. Machida, M. Sasakawa, and P. K. Patra

Response to Reviewers

Anonymous Referee #3

Nomura et al., present a new set of measurements from two sites on the Indian subcontinent, Nainital in northern India and Comilla in Bangladesh. Despite its large contribution to global greenhouse gas emissions, and the potential for future growth, atmospheric measurements from the region – required for top-down estimation of GHG emissions – are sparse. The analytical techniques described are appropriate, though I would like to see some additional information (see comments below), and the measurements themselves appear to be of high quality. For these reasons, the data presented merits publication in ACP, though I would like to see some consideration of the following points:

>Thank you very much for reading the manuscript. We appreciate your constructive comments and suggestions.

Major comments: L103 – the authors state that they have estimated a small contribution from local sources. This might well be the case, but it would be good to know how this was estimated. The nearest populated region is fairly close for a background station, can the authors be sure that this urban area is not having a large effect on the measurements at NTL?

>NTL is located the edge of Himalaya Mountain and faced the Indo-Gangetic Plain. The wind at NTL blows always from Indo-Gangetic Plain and the wind speed of NTL is 3-10 m/sec. The seasonal variation of GHGs mole fraction at NTL are stable every year. Also, the value of SF6 mole fraction is stable and almost same level with MLO, despite that major source of SF6 exist in the city. The representative nearest populated cities for NTL are Nainital city and Haldwani city. Those are located about 2 km northwest and 20 km southeast of the NTL site, representatively. Nainital city is leeward site of NTL site for most of the year and the altitude of Haldwani is 1000-m lower than the altitude of NTL. Therefore, atmosphere of NTL might be partly influenced by the nearest populated areas, however, mainly influenced by relatively larger air mass over western Indo-Gangetic Plain in terms of high altitude of the sampling site, wind condition, seasonal variation patterns of all observed GHGs.

L112 – similar to my last comment, how can the authors be sure that CLA is not overwhelmingly influenced by local emissions. The inlet at CLA is fairly low (8 magl), and I would be concerned that

local burning, agricultural emissions etc. might regularly 'drown out' regional signals. This requires some additional discussion in the main text.

> If CLA is influenced strongly by the emission from the farmer houses and Comilla city, we could see frequently the episodic CO enhancement by the biomass burning. However, the enhancement of CLA is hardly happen. Also, the seasonal variation of CO mole fraction at CLA are stable every year. The land use of the central region of Bangladesh is almost uniformity (small farming village and large paddies field) in a sense and geographical features is a flat. Therefore, we could see typical seasonal variation in this region, if we can avoid very local emission. Wind blows always over CLA, even though the speed is relative slow as 2-5 m/sec. We concluded that the atmosphere of CLA was influenced mainly by the air mass of large rural area of the central Bangladesh region from such situation and the GHG data (the stable seasonal variation of GHGs and no episodic CO enhancement of CLA). We added some sentences to the text according to above context.

L122 – given this is a 'measurement report', I would like to see some more detail on how the measurements were conducted. For instance, what was the procedure for analyzing CO2 on the NDIR. Is the final measurement on average of a set-length injection? How often was the standard analyzed? It would also be good to see the average measurement precision for each species.

>We added the sentence of "Sample was injected to the analytical system three times per one flask and the working standard gases were analyzed after every two flasks." In L136-137.
We added the sentences of "The mole fractions of respective working standard gases are 379.00, 403.01, 423.84 and 441.10 ppm for CO2, 1681.50, 1852.12, 1998.83 and 2167.63 ppb for CH4, 59.84, 164.57, 267.33 and 373.54 ppb for CO, 401.40, 502,98, 610.49, 715.95 ppb for H2, 319.23, 326.91, 337.53 and 345.54 ppb for N2O and 4.65, 9.77, 14.53 and 19.08 ppt for SF6." And " Analytical precision for repetitive measurements is less than 0.03 ppm for CO2, 1.7 ppb for CH4, 0.3 ppb for CO, 3.1 ppb for H2, 0.3 ppb for N2O, and 0.3 ppt for SF6 (Machida et al., 2008)." in L144-148.

L169 – the back-trajectories shown are single particle trajectories. These trajectories don't appear to indicate when the particle is within close contact with the surface, and when it isn't. Without such information, the trajectories don't offer much additional information, e.g. a trajectory may originate over the Indo Gangetic Plain, but if the particle is many kilometers above the surface, it is unlikely to interact with potential sources? At the very least, this needs to be acknowledged in the main text.

>We calculated altitude with latitude and longitude on the back trajectory analysis and we checked that the air mass at NTL and CLA passed through the atmospheric boundary layer from the data of

altitude. We added the sentence of "We referred the altitude data when we evaluated the effects of GHGs emissions sources near the surface." in L190-191.

L179 – I share the concerns of reviewer 1 with regards to the averaging of data into 10-day averages. It would seem to make more sense to calculate the long-term trends from the raw weekly data, as opposed to applying an average that in some cases only includes 1 data point. I would recommend calculating the long-term trends from the raw data or provide more detail on why a 10-day average is appropriate.

>The date intervals of the original data must be qual interval in order for our script for calculating only the "long-term trend" and "smooth fitting curve" (based on FFT). Basically, the date interval of the flask sampling is every 7 days. But irregularly, the date intervals are 6 days, 8 days or 14 days. The reason for setting 10-day means is to reduce missing data in intervals smoothing the original data and to run our script. Also, we calculated the long-term trend and a smooth fitting curve from the data set as the date intervals of 7-days mean (The mean is put the dummy data during the missing periods), 20-days mean and 30-days mean and checked those values. For other evaluations such as scatter diagram and seasonal variation, we used individual data itself. We added one sentence for explanation in the section.

L280 onwards – I expect to see plenty of detail in a measurement report, but I found much of the results section to be overly verbose, to the point that it detracted from the main points of discussion. I would suggest that the results section of the paper would benefit from some shortening, and that the authors concentrate on some of the more important findings. Specific examples:

>We removed several sentences to concentrate our discussion.

• L263:300 – discussion of the different crop cycles is interesting, but does could be shortened and references condensed

>We removed below sentence
"Especially, the CO_2 mole fraction at CLA in February–March decreased remarkably, by up to approximately 8 ppm."

"In the region near NTL, rice, wheat, and other cereals and millets were mainly cultivated (DAC/MA, 2015; SID/MP, 2018; and DES/MAFW, 2019)."

"Panigrahy et al. (2010) reported the main rice growing seasons in North India to be July–September and February–March by using the Normalized Difference Vegetation Index (NDVI). Nayak et al. (2010) also reported that Net Primary Productivity (NPP) on the Indo-Gangetic Plain increased in August–September and February–March, estimated from the NDVI".

• L454-482 – the conclusion that CO variability is linked to crop residue burning is compelling, however the same conclusion could be reached with significantly less text

>We removed the sentence of "(i.e., two mole fraction peaks in May and November)" and "Sharma et al. (2010) suggested that the high CO mole fraction on the Western Indo-Gangetic Plain is emitted in October by the burning of harvest residues, based on data from satellite observations.".

Technical corrections:
L42-43 – end of first sentence needs restructuring

>We changed "The atmospheric mole fractions of CO_2, CH_4, N_2O and many other greenhouse gases (GHGs)" to "The mole fraction of many greenhouse gases (GHGs) in the atmosphere, including CO2, CH4, and N2O, has been increasing worldwide in recent years." in L43-44.

L43 – 'emerging' seems like a poor choice of word here. Perhaps 'developing' would be more appropriate

>We changed "developing" in L44 as suggested.

L82 – need to subscript CO2 L88 – 'believed to be' L209 - 50–470 ppb of what? L339 – typo 'fairy' needs to be corrected to fairly

>We changed "CO_2" as suggested.
>We changed "believed to be" in L91 as suggested.
>We changed "50-470 ppb for CH_4" in L227 as suggested.
>We changed "fairly" in L354 as suggested.

L395 – the seasonality at Darjeeling is within the uncertainty of the seasonality estimated for CLA. Are the sources near to CLA similar to those at Darjeeling?

>Darjeeling is affected by the flesh air mass from the South Hemisphere in the monsoon season and the air mass with the high CH4 concentration from the paddies field in Indo-Gangetic Plain in the non-monsoon season like CLA. But, CH4 mole fraction at Darjeeling is lower than that of CLA because CLA are located at t the central area in vast paddies field region.

L492 – mainly should be ‘main’

>We changed “main” in L 508 as suggested.