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Interactive Comment

Interactive comment on "The variability of methane, nitrous oxide and sulfur hexafluoride in Northeast India" *by* A. L. Ganesan et al.

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We thank the reviewer for his valuable comments and provide responses below. Reviewer comments are provided with author's response following each comment.

Author's comment: We have changed the citation for the pre-industrial SF6 concentration from Deeds et al., 2008 to Vollmer et al., 2002 (P3L51).

-Vollmer M.K., et al., Marine Chemistry, 78, 137-148, 2002

Page 3 Line 6 and others: do not begin sentences with chemical formulae Line 7: Table 2.1 in Forster et al. 2007 shows that in 2005 N2O is the 4th largest RF due to LLGHGs, CFC-12 is 3rd; N2O did not surpass CFC-12 until 2009

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Interactive Discussion

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Response: Sentences beginning with chemical formulae have been changed throughout the text.

The citation for nitrous oxide radiative forcing has been changed to:

-Hoffman D.J., et al., The role of carbon dioxide in climate forcing from 1979-2004: Introduction of the Annual Greeenhouse Gas Index, Tellus B, 58B, 614-619.

-Montzka, S.A., et al., Non-CO2 greenhouse gases and climate change, Nature, 476, 43-50.

Page 4 Line 7: Many new references on N2O budgets that should be reviewed here, in particular Park et al. Park, S., P. Croteau. K. Boering, D. Etheridge, D. Ferretti, P. Fraser, K.-R. Kim, P. Krummel, R. Langenfelds, T. van Ommen, P. Steele & C. Trudinger, Trends and seasonal cycles in the isotopic composition of nitrous oxide since 1940, Nature Geoscience, 5 (4), 261-265, 2012 Saikawa, E., ...R. Langenfelds, P. Krummel, M. van der Schoot, P. Fraser, P. Steele et al., Global and regional emissions estimates for N2O, Atmos. Chem. Phys. Discuss., 13, 19471-119525, 2013 Thompson, R., ...R. Langenfelds, P.Krummel, P. Fraser, P. Steele et al., Inter-annual variability in tropospheric nitrous ox- ide, Geophys. Res. Letts., 40, 1-6, doi:10.1002/grl.50721, 2013 Thompson, R., . . .R. Langenfelds, P. Krummel, P. Steele, P. Fraser et al., Nitrous oxide flux history 1999- 2009 from an atmospheric inversion, Atmos. Chem. Phys. Diss., 13, 15697-15747, 2013

Response: We thank the reviewer for his attention to these recent publications.

We have updated the manuscript to include global emissions estimates from Park et al., 2012, Saikawa et al., 2013 and Thompson et al., 2013 and South Asian regional emission estimates from Saikawa et al., 2013.

The text now states, “Global N2O emissions were estimated to be 17.2-20.1 TgN/yr from 2005-2009 and global SF6 emissions were found to be 7.2–7.4 Gg/yr in 2008 [Saikawa et al., 2013, Thompson et al., 2013, Park et al., 2012, Rigby et al., 2010,

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Levin et al., 2010]. . ... In another study, aggregated South Asian and Southeast Asian N2O emissions were deduced using global network and Cape Rama data to be 3.63 TgN/yr in 2008 [Saikawa et al., 2013]."

Page 6 Line 5: use metric units, not feet and inches

Response: Metric units have been provided in addition to English units throughout the text of the Experimental Methods section. As instrument components were purchased in the United States, the exact dimensions are first provided in feet/inches.

Page 10 Line 27: Comment as quantitatively as possible on the performance of the model in comparing modelled and observed wind speed and direction

Response: The text provides a discussion about the performance of the model in capturing the observed features in wind speed and direction. The text states, "To assess the ability of the UM to reproduce flows at the site as well as to understand the origin of air masses sampled at the site, observed and modeled wind speeds and wind directions are compared using wind roses (Fig. 3). UM modeled winds are shown at 500 m.a.g.l., which is the mid-point particle release height used in the model.

Horizontal wind speeds at Darjeeling maximize in April (not shown) during the pre-monsoon period and minimize in July when vertical motion is strong in the Himalayas. Wind speeds are almost always larger in the 500 m.a.g.l. model winds than in the 15 m.a.g.l. observed winds because surface friction is less significant at this height in the model. In January, 500 m.a.g.l. modeled and observed winds at 15 m.a.g.l. show good agreement in wind direction. Air flow is southerly during the day and northeasterly at night, which is consistent with the direction of plains-to-mountain winds. Upslope and downslope winds local to the Darjeeling ridge, which is oriented towards the northeast, would result in observed and modeled diurnal winds that are oriented to the southeast and northwest, respectively if the flow being captured was a local process. This diurnal shift in wind direction, which is well-captured by the model, is responsible for the "lobes" seen in the winter air history maps (Fig. 2). In July, the diurnal cycle in wind direction is not significant and this lack of diurnal cycle is reproduced in the model as well. Both the model and observations show a consistent southeasterly wind direction at this time, resulting from air masses that originate from the southwest but first pass over the Bay of Bengal before reaching Darjeeling from the southeast. The consistency between the model and observations suggest that the air sampled at Darjeeling is representative of the “large-scale” flows of the region rather than the local mesoscale flows.

This comparison has been performed for a variety of model heights. Only small differences exist in the meteorology at heights between 400-600 m.a.g.l., but surface meteorology shows a better fit wind speed and a worse fit for wind direction. This tradeoff between wind speed and wind direction at the release height could contribute to errors in the derived air histories."

Page 12 Second para: quantify by data analysis the ‘monsoon effect’ on the concentration data – my analysis would suggest that SF6 is 0.15 ppt below mean during the height of the monsoon season

Response: Thank you for this comment and your analysis.

The text now states, “A linear fit was applied to the SF6 data (excluding monsoon months of June to September) and interpolated to mid-July. This represents the value, to first-order, that would be expected given only NH air. The observed July data was averaged into weekly values and compared to the interpolated NH-air value. A difference of 0.13 pmol/mol was found at the peak of the monsoon. Previous studies have shown a seasonal SF6 amplitude of 0.17 pmol/mol at the Seychelles [Gloor et al., 2007]. It is expected that the difference at Darjeeling, which is a continental site, would be smaller than that observed at the Seychelles because SH air entering India first passes over eastern Africa and the Indian subcontinent before reaching Darjeeling.”

Page 17 The data can only be used to verify national emissions once a much longer record is obtained – minimum 3 years, preferably five year to give 4 years of a 3-yr running average.

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Response: Text has been modified to "..these data will be used to constrain national-scale emissions from South Asia."

Interactive comment on Atmos. Chem. Phys. Discuss., 13, 17053, 2013.

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