Atmos. Chem. Phys. Discuss., 15, C8121–C8123, 2015
www.atmos-chem-phys-discuss.net/15/C8121/2015/

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Atmospheric constraints on the methane emissions from the East Siberian Shelf" *by* A. Berchet et al.

A. Berchet et al.

antoine.berchet@empa.ch

Received and published: 16 October 2015

We thank the reviewer for his detailed, precise, and very useful comments and suggestions on our manuscript. We acknowledge the fact that the text has to be improved in precision and clarity in the specified zones. The numerous comments and suggestions of the reviewer will be of great help to do so, when we work on a revised version of the manuscript after the open discussion period. At this moment we will provide a point-by-point answer to all comments and suggestions but today, we would like to answer to one major comment of reviewer one concerning isotopic data.

We agree that the text of section 3.1 presenting the use of ^{13}C observation to constrain the source of air sampled at ZEP and coming from ESAS and Ob regions needs

some clarification. Our main point is that only a dominant biogenic source is consistent with observed ^{13}C when air is coming from these regions. This can be due 1) to the microbial decomposition of recently thawed C-rich sub-sea permafrost which eventually reach the atmosphere, 2) to the destabilization of marine hydrates trapped below a thawing and failing sub-sea permafrost, and 3) to a biogenic continental source (wetlands, freshwaters, or microbial production after continental permafrost melting). Quantifying the fraction of air coming from the different source regions (ocean, continent) with our transport model, it is possible to show that emissions coming from ESAS should be very depleted in ^{13}C (-70/-75‰ and that hydrates cannot explain the observed signals, but we cannot make a partition between oceanic or continental biogenic source. We revised the specific text of this paragraph and propose the following (hopefully clearer) text:

Revised section 3.1

3.1 Summer isotopic observations in the Arctic

The isotopic composition in ^{13}C of Arctic air brings insights on the origin of the methane sources. Indeed, Arctic surface emissions mixed into the atmosphere own very different isotopic signatures (Fisher et al., 2011; Milkov, 2005): typically of -40 to-55 ‰ for gas leaks (thermogenic origin), -50 to -55 ‰ for marine hydrates (thermogenic and biogenic origin) and -60 to -75 ‰ for wetlands and biological degradation of thawing permafrost (biogenic origin). We use here δ^{13}C measured at ZEP observatory in combination with CH_4 concentration measurements in September 2008 and September-October 2009. During the observation campaigns, episodes with identified air origin from River Ob and Eastern Siberia exhibited a mean signature of -65 $\pm$ 3 ‰ in September 2008 (Fisher et al., 2011) and of -68 $\pm$ 5 ‰ in 2009 (see Fig. 3). These values point toward a dominant biogenic origin of emitted methane. More precisely, in these air masses, the contribution of the different methane sources can be estimated as they

are run separately in the CHIMERE model. ESAS emissions are found to contribute 40-50% to the observed signals (with ESAS emission strengths from Shakhova et al., 2010), continental wetlands contributing to 30-35% and fossil fuels to 20-25%. Using these relative weights, together with the range of associated source isotopic signatures, it is possible to calculate the integrated isotopic signature of sources at ZEP during the abovementioned episodes. With a reference scenario of 8 $TgCH_4.y^{-1}$ for ESAS emissions, it is found that only isotopic signatures in the range of -70 to -75‰ for ESAS source are compatible with the observations. This points at a purely biogenic origin. Conversely, if ESAS emissions were made entirely by degassing of hydrates trapped under the sub-sea permafrost, the simulated δ^{13}C signature at ZEP would be in the range of -51 to -61 ‰ thus not compatible with the δ^{13}C observations. Our methodology does not allow proposing a partition of this biogenic contribution between degrading thawing marine permafrost and continental biogenic emissions, which are mostly related to wetlands and freshwaters, but it is possible to eliminate a dominant hydrate contribution. To go further, a full atmospheric inversion assimilating both ^{13}C and ^{12}C observations in addition to CH_4 concentrations in the transport model would be necessary, which is beyond the scope and objectives of the present paper.

Interactive comment on Atmos. Chem. Phys. Discuss., 15, 25477, 2015.