Atmospheric CH_4 distributions observed during Arctic cruises of R/V Mirai in 2012-2015

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Several researches pointed out the concern that methane emissions in the Arctic region would increase in near future due to global warming. To investigate the CH_4 potential sources in the Arctic region, continuous measurements of the atmospheric CH_4 were conducted onboard a R/V Mirai during 4 Arctic cruises: MR12-E03 (Sep. 3-Oct. 17, 2012), MR13-06 (Aug. 28-Oct. 17, 2013), MR14-05 (Aug. 31-Oct.10, 2014), MR15-03(Aug. 23-Oct. 5, 2015). The onboard measurements of the atmospheric CH_4, carbon dioxide (CO_2) and carbon monoxide (CO) were carried out by using a cavity ring-down spectroscopy (CRDS) analyzer (Picarro, G2401). The estimated analytical precisions were about 0.02 ppm (CO_2), 0.3 ppb (CH_4), and 1 ppb (CO) for the 5-min averages when the CRDS analyzer was in good condition. However, the precisions were considerably worse for CO during MR13-06 cruise, CO_2 and CO during MR15-03 cruise, and CH_4 during the latter half of the MR15-03 cruise because of malfunctions of the CRDS analyzer. It should be noted that the CO_2 and CO mixing ratios were sometimes contaminated by the own exhaust fumes while there was no significant influence from the exhaust fumes on the CH_4 mixing ratio. Such pollution events are easily distinguishable by the characteristics of the relative wind direction, the tight correlation of CO vs. CO_2, and large short-term (~a few second) variability of CO_2.

From these Arctic cruises, distribution of the atmospheric CH_4 in the Bering Sea, the Chukchi Sea, and the Canada Basin of the Arctic Ocean in September were mainly observed. For the individual cruises, relatively elevated CH_4 mixing ratios of several tens ppb were observed in the Bering Strait, Chukchi Sea, and off the northern Alaskan coast (Fig. 1). Since these elevated CH_4 peaks were generally associated with similar CO_2 peaks but not with CO peaks, it's unlikely that the ocean or combustion processes were the sources of the elevated CH_4. To examine the relationship between the CH_4 variations and the air mass transport, 3-day backward trajectories along the cruise tracks are computed by using the METEX (METeorological data Explorer, http://db.cger.nies.go.jp/metex/) developed by Zeng et al. (2003).The backward trajectory analysis suggests that the elevated CH_4 are associated with the air mass transport from Alaska or East Siberia, especially North Slope of Alaska (Fig. 2). Simulated CH_4 variations based on an atmospheric transport model and reported CH_4 flux map well capture the observed CH_4 variations, also suggesting that the most of elevated CH_4 were derived from the land sources. However, the amplitudes of the elevations are not necessarily reproduced well. These results suggest that the observed CH_4 spatiotemporal variations could be used to improve the CH_4 emissions from the Arctic regions.

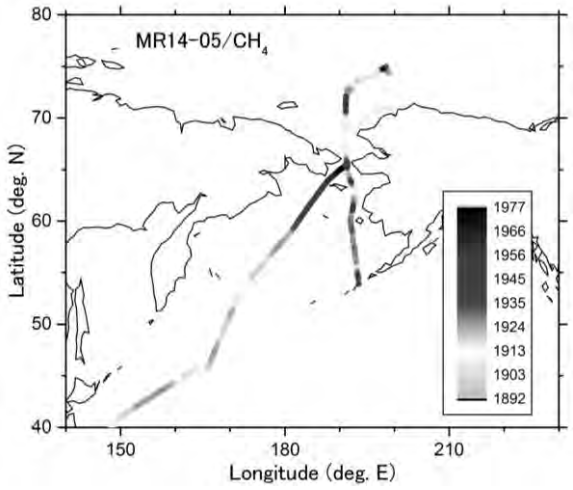

Fig. 1. CH_4 distribution along the track of the MR14-05 cruise.

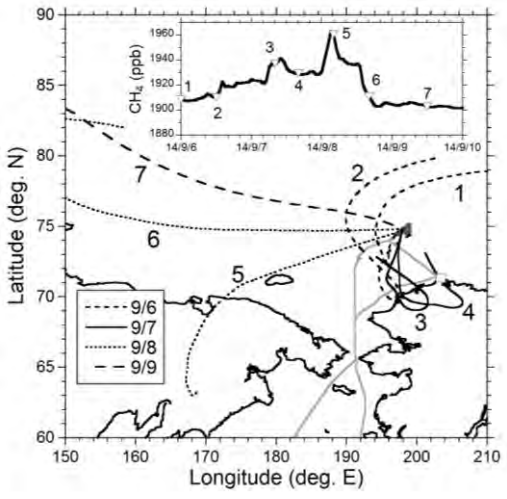

Fig. 2. 3-day backward trajectories along the cruise track for 4-day period during the MR14-05 Arctic cruise. Inserted figure shows time series of CH_4 mixing ratio.

References

Zeng, J., Y. Tohjima, Y. Fujinuma, H. Mukai, and M. Katsumoto, A study of trajectory quality using methane measurements from Hateruma Island, Atmos. Environ., 37, 1911-1919, 2003.