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Interactive comment on "Winter observations of CO_2 exchange between sea-ice and the atmosphere in a coastal fjord environment" *by* J. Sievers et al.

M. Helbig

manuel.helbig@umontreal.ca

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The manuscript by Sievers et al. addresses important research questions about CO_2 flux dynamics over snow covered sea ice. For this study, two different infrared gas analysers (IRGA) (an open- and a closed-path IRGA) are used at three different sites to describe the spatial variability of winter CO_2 flux dynamics. The CO_2 flux measured at the site equipped with the closed-path IRGA does not show a significant relationship with sensible heat flux, while CO_2 fluxes at sites that deploy the open-path IRGA show a strong and significant relationship with sensible heat flux. In this context, the differing sources of uncertainties in open- and closed-path IRGA derived CO_2 fluxes

need to be considered to ensure comparability between the sites. While air temperature fluctuations are strongly dampened in the measurement cell of the closed-path IRGA, the sensing path of the open-path IRGA is exposed to high-frequency, ambient air temperature fluctuations. At sites with small CO_2 fluxes, the CO_2 density fluctuations measured by the open-path IRGA are often mainly driven by air temperature fluctuations. These density effects are removed by applying the WPL term. However, systematic biases in the measurements of the sensible and latent heat fluxes and/or in the measurements of the raw CO2 fluxes (i.e. after spectral correction, but before the application of the WPL term) would propagate to final CO_2 fluxes and could introduce an apparent relationship between winter CO_2 fluxes and sensible heat flux. A detailed overview of these systematic uncertainties is given by Liu et al. [2006]. Furthermore, biases in the measurements of mean CO_2 and H_2O densities could introduce a similar bias in the final CO_2 fluxes via the application of the WPL term [Serrano-Ortiz et al., 2007].

A previous reviewer has highlighted the importance of considering possible surface heating effects on CO_2 flux estimates derived from the LI7500A. To my knowledge, there hasn't been any peer-reviewed paper that demonstrates the reduced surface heating effects of the LI7500A. However, it seems unlikely that the observed CO_2 fluxes at the sites equipped with the LI7500A are strongly affected by surface heating. If surface heating would be mainly caused by solar load, then we would expect a strong correlation between CO_2 fluxes and incoming shortwave radiation during the day and incoming shortwave radiation during the night [Burba et al., 2008]. This is not the case in this study (see Fig. 5 in this manuscript). Instead, net radiation and, even more so, the sensible heat flux is strongly correlated with the open-path IRGA derived CO_2 flux.

A relationship between the difference of CO_2 fluxes derived from a LI7500 and paired closed-path IRGAs and sensible heat fluxes has been observed by Hirata et al. [2007] and Ono et al. [2008]. Hirata et al. [2007] found the largest differences between CO_2 fluxes derived from a LI7500 and a paired closed-path LI6262 during the growing sea-

son, and not during the winter. Also, the study by Ono et al. [2008] was conducted in April in Japan with soil temperatures at 5 cm ranging between 10 °C and 15 °C. While we would expect the largest surface heating effects during wintertime, a systematic bias related to an underestimation of the WPL term (as described by Liu et al. [2006] and Serrano-Ortiz et al. [2007]) would directly scale with the magnitude of the sensible heat flux itself, as observed by Hirata et al. [2007] and Ono et al. [2008]. Furthermore, the issues raised by Liu et al. [2006] and Serrano-Ortiz et al. [2007] are valid for all open-path IRGA based systems and are not restricted to the use of a specific instrument, as might be the case for the surface heating problem.

Given the strong sensitivity of errors in final CO_2 fluxes derived from open-path IRGAs to errors in sensible heat fluxes and/or raw CO_2 fluxes, I would recommend a more thorough discussion and/or quantification of systematic uncertainties inherent to the CO_2 fluxes derived from the LI7500A to support the results of this manuscript.

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