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Can sea ice-specific biogeochemical processes support significant air-ice CO2 fluxes?

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There are growing observations that sea ice exchange CO2 directly with the atmosphere and that the partial pressure of CO2 (pCO2) within sea ice is highly dynamic, ranging from extreme over-saturation to extreme under-saturation. To explore the relationships between sea ice-specific biogeochemical processes and fluxes of CO2 at the air-ice interface, we carried out three surveys which addressed spring and summer in Antarctic land fast sea ice, and first year and multiyear pack ice. Spring and summer pCO2 patterns are consistent between the three surveys and mainly result from physical processes (temperature increase and related melting, convection of brines,Ě) while the under-saturation observed in summer is the signature of chemical (dissolution of carbonate minerals) and biological processes within sea ice. Exchanges of CO2 at the air-ice interface are unsurprisingly driven by the evolution of pCO2 within sea ice, yet modulated by sea ice permeability. Cold ice is generally not permeable either to gas or water transfer. As temperature crosses the threshold value of about -5°C, sea ice becomes permeable to gas, and sea ice begins to release CO2 to the atmosphere at a rate up to 1.9 mmol.m-2.d-1. However, as the ice continues to warm up, pCO2 decreases dramatically to reach under-saturation of CO2 (pCO2 down to 30 ppmV). and sea ice turns into a CO2 sink with CO2 fluxes ranging up to -6 mmol.m-2.d-1. First tentative, and probably underestimated, budgets of air-ice CO2 fluxes point out that Antarctic sea ice edge would represents an additional CO2 sink of 6 to 9 % to the current estimate of the uptake of the Southern Ocean south of 50°S. We assessed how

realistic could be such CO2 fluxes by estimating the potential CO2 fluxes driven by each main sea ice biogeochemical processes. This independent assessment is consistent with estimates derived from air-sea CO2 fluxes measurements and point out the significance of abiotic sea ice-specific biogeochemical processes.