More frequent spaceborne sampling of XCO2 improves detectability of carbon cycle seasonal transitions in Arctic

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Field measurements, towers, aircraft, and satellites indicate pervasive cold season CO_2 emissions across northern high latitude tundra and boreal ecosystems. Ongoing emissions over the last several decades are consistent with a hyperactive biosphere, characterized by increased photosynthetic uptake in summer and increased respiration of labile carbon in the cold season. The key remaining question is if, and when, cold season sources, including those from underlying permafrost, become large enough to permanently shift the Arctic into a net carbon source. Satellites such as the Orbiting Carbon Observatory (OCO-2), which map gradients of CO_2 in time and space, have greatly advanced our ability to track shifts in carbon balance during the daylit portion of the year. However, polar orbiting satellites generally lack sufficient spatial coverage and repeat frequency needed to track seasonal shifts in carbon balance; in particular, spatial gradients in the timing and magnitude of sink-to source transitions in the early cold season. The Arctic Fourier Transform Spectrometer Investigation (AURORA) mission concept has potential to address sampling limitations and provide more detailed understanding of pan-Arctic carbon cycling. AURORA offers key innovations in instrument design and observing platform needed for pan-Artic carbon cycle studies, including a highly elliptical orbit (HEO) with increased repeat frequency, and a panchromatic imaging Fourier Transform Spectrometer which uses a wide spectral range (0.7–15.4 μm) encompassing both reflected solar and thermal emission bands to improve sensitivity to the lower troposphere. We perform retrieval simulations for different atmospheric, land surface, and time of year conditions in northern high latitudes, and report on flux retrieval performance relative to OCO-2, focusing on the impact of sub-daily shortwave CO_2 retrievals. The results demonstrate the benefits of increased sampling frequency for detecting spatial gradients in cold season efflux in the Arctic using combined OCO-2 and AURORA. The proposed concept is expected to improve detection of both slow and rapid carbon cycle changes in the Arctic.

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