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## Hysteresis of terrestrial carbon cycle to CO<sub>2</sub> ramp-up and -down forcing

Sowon Park and Jong-Seong Kug

Pohang University of Science and Technology (POSTECH), Division of Environmental Science and Engineering, Korea, Republic of (sowon@postech.ac.kr)

**To prevent excessive global warming, we have faced a situation to reduce the net carbon dioxide (CO<sub>2</sub>) emission. However, how the Earth's terrestrial biosphere behaves under negative emission is highly uncertain. Here we show that there is a strong hysteresis in terrestrial carbon cycle in response to CO<sub>2</sub> ramp-up and -down forcing. Due to this strong hysteresis lag, terrestrial biosphere stores more carbon at the end of simulation than its initial state, lessening the burden on the net negative emission. This hysteresis is latitudinally-dependent, showing a longer timescale of reversibility in high-latitudes and particularly carbon in boreal forests can be stored for a long time. However, the hysteresis of the carbon cycle in the pan-Arctic region strongly depends on the presence of permafrost processes. That is, an unexpected irreversible carbon emission might occur in permafrost even after achieving net-zero emission, which implies the importance of the permafrost processes, highly uncertain in our current knowledge.**