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Asynchrony of winter soil freeze-thaw phenology induced by warming reduces ecosystem respiration of alpine meadow during the freeze-thaw period

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Changes in winter soil freeze-thaw (F-T) phenology not only affect nature, but also affect social-economy in permafrost regions. However, a lack of understanding of its response to global warming is a critical gap in knowledge to preclude adaptation to climate change. Here we explored effects of warming gradient (0, 1, 2 and 4^{o}C) combined with precipitation addition on it by which further on CO_2 emission on the Tibetan Plateau. We find that only warming delays start and end dates of soil F-T cycle during autumn-winter season, but advances them during winter-spring season, thus shortens the durations of completely freezing (14.9 days $^{o}C^{-1}$) and total duration of soil F-T period from autumn to spring (11.7 days $^{o}C^{-1}$). Thus, asynchronic shifts of the soil F-T cycle induced by warming significantly decreased total CO_2 emission by 31-47% relative to T_0 treatment during the whole F-T period from autumn to spring.