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Additive linearity of atmospheric responses to Arctic sea ice reduction and La Nina

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Previous studies documented that both Arctic sea ice reduction and La Niña results in significant cooling in winter surface air temperature in midlatitudal Eurasia. Since the two forcings sometimes occur simultaneously, whether they are independent of each other is analyzed first. The result suggests an overall independence. Considering their individual significant impacts and the possible interaction between the impacts, the coordination of the impacts from the two forcing on northern hemispheric winter climate is then investigated based on observational analyses and atmospheric general circulation model (AGCM) sensitive experiments. The results suggest that the two forcings overall linearly accumulate their impacts, resulting in intensified cooling in mid-latitudinal Eurasia along with north-warmer-south-cooler dipolar air temperature anomalies over North America. Despite their overall additive linearity, nonlinear interaction between the two impacts is also identifiable. The nonlinearity causes midlatitudinal Eurasian cooling weaker than the sum of those induced by sole sea ice reduction and La Niña forcings. Additive linearity and nonlinearity in atmospheric circulation accounts for those in air temperature anomalies. One substantial consistence is seen between the observational analyses and the AGCM experiments, thus the additive linearity and nonlinearity is robust.